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Primary school teachers' experience of mathematics education: A phenomenological study

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Abstract

Researchers and policymakers agree that all children can learn mathematics, and research has shown that teaching practices have a significant impact on student learning and achievement. Therefore, it is important that teachers are supported in their development as professionals and mathematics educators. This research gives a voice to a small number of primary school mathematics teachers, providing insight into their experience of mathematics education, from their perspective. In-depth interviews form the basis of data collection and these have been analysed through a transcendental phenomenological approach. The insights gained into teachers' experiences and perspectives provide a deeper understanding of their role and opens the door to a necessary conversation on what success in mathematics looks like and how it can be best supported. The feeling of being time-poor was significant, contributing to a situation where teachers faced a choice between what they think would be best for students and meeting external requirements. The participants described how different schools vary, and how different working environments have impacted their experience of mathematics education. These new understandings have implications for policymakers, school leaders and professional learning providers, as they lead to recommendations regarding the curriculum, supportive working environments, and necessary resources for teachers.

Statement of Original Authorship

I certify that this thesis does not, to the best of my knowledge and belief:

i. incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education;

ii. contain any material previously published or written by another person except where due reference is made in the text of this thesis; or

iii. contain any defamatory material.

Signature: [redacted]

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Table of Contents

List of Figures

List of Tables

Research Outputs

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Preface

It can seem simple, 1+1=2. Before starting school, children often play hide and seek, counting up to ten verbally unaware of the potential meanings and applications of these words. At school, each child becomes a student. What happens next?

We have all experienced mathematics education. Did you enjoy it? Why does this subject, more than others, seem to evoke strong emotions?

Looking at international comparisons and media announcements, there is ongoing concern in Australia over the number of students engaging with and achieving in mathematics. What is success in mathematics? Why do so many ‘fail’?

This thesis identifies challenges and successes in teaching mathematics, weaving together what is already known about mathematics education with what is discovered – insight into the lived experiences of primary school teachers. What comes through is that teachers are human, people striving to meet deeply held expectations and needs: theirs and the child’s – and the parent’s, and the school’s, and the education authority’s…

I have always loved mathematics. My passion for and interest in this subject extended as I transitioned from student to teacher, and I have always been keen to share my enthusiasm. When I discovered that, according to international testing, nearly a third of Australian students have been consistently performing at or below the low international benchmark, this propelled me on a journey of research. My curiosity consumed me: Why is this happening? What can I do to help? I know that not everyone has the same passion for mathematics as I do, and it is hard to imagine what the usual experience of teaching mathematics might be like. I read the literature but it did not tell me how primary school teachers perceive and experience mathematics education. Only with this knowledge could I begin to understand the situation sufficiently to know what might help improve mathematics education - for teachers and learners. It has been fascinating and fulfilling to explore this topic in depth, from the teachers’ perspective. Learning mathematics is not simple. The tensions and struggles addressed in this thesis highlight why, and point to possible solutions.

Chapter 1: Introduction

This chapter outlines the background of the study, the research problem and significance of the study. The research questions are stated and an overview of the thesis is given.

1.1 BACKGROUND

Teachers of primary school mathematics in Western Australia are not, generally, mathematics specialists. Primary school teachers work to a set of professional standards to provide pastoral care for students and to educate them in all, or most, of the primary curriculum. This curriculum includes English, Humanities and Social Sciences, Health and Physical Education, Technologies, Science, Languages, and the Arts (School Curriculum and Standards Authority, 2014b). The curriculum provides teachers with information on content to be covered and associated achievement standards. However, it has been asserted that the curriculum is crowded, giving teachers advice on what needs to be done with little guidance on how to do it (Hurst, 2015a).

Assessments aim to gauge what students know and can do, but mathematics education involves more than simply transferring a body of knowledge from the teacher to the student. The mathematics classroom environment is complex and influenced by a variety of factors, including: knowledge and beliefs of the teacher and the students; leadership and culture within each school; background of the students; and policies, curriculum, resources and funding (Connell, 2009). It is beyond the scope of the current study to investigate every factor in detail. However, as the teacher's work is directly impacted by each of these factors and a teacher's approach, knowledge and subsequent practice greatly influences student outcomes, the current study aims to explore the experience of mathematics education from the perspective of primary school mathematics teachers.

Within the context of this study, the term 'mathematics education' incorporates both the teaching of mathematics and how children learn mathematics. In this sense, the term acknowledges that teachers are at once teaching and learning, that it is not possible to effectively plan a lesson without some knowledge of how children learn, or to successfully implement a lesson without responding appropriately to how children are learning in response to the teaching. Teachers are constantly reflecting and reflexive, learning through their practice, either new content, how better to teach, or what challenges may arise as students learn.

Primary school teachers all start with some knowledge of the mathematics curriculum from their own experiences as students of mathematics in school and from their initial teacher training at university. In order to teach mathematics, it is not sufficient for teachers to simply be proficient at mathematics themselves, they also need to have an in-depth understanding of the content, concepts and connections (Jorgensen & Dole, 2011). Furthermore, if mathematics is taught in separate content strands, with no connections made between concepts, strands or other curriculum areas, there is a negative impact on student learning and on a student's ability to see connections between the subject of mathematics and the world outside of school (Jorgensen & Dole, 2011). A teacher's awareness of hypothetical learning trajectories, a term coined by Simon (1995), is used to design an appropriate sequence of activities to support students along their natural path of mathematical development.

Cognisant of connections and learning trajectories within mathematics or not, identifying a student's misconception or gap in knowledge can be challenging. This is because a child may give a correct answer whilst having, unbeknown to the teacher, used a strategy based on a misconception. Early intervention is important because of the cumulative effects of gaps in understanding (Jordan, Kaplan, Ramineni, & Locuniak, 2009). A lack of understanding of number relations and operations, for example, has been shown to hinder a child's ability to access other areas of the mathematics curriculum, to develop fluency, and to extend his or her learning to involve larger numbers or problem solving (Jordan et al., 2009).

Research suggests that teaching practices and insufficient teacher knowledge is linked to students' learning difficulties and therefore to student achievement (D. L. Ball, Thames, & Phelps, 2008; Beswick & Goos, 2012; Heyd-Metzuyanim, 2013; Kleinhenz & Ingvarson, 2004), and it was recognised in 2008 that mathematics pedagogy has rarely been the focus of primary school teachers' training (Westwood, 2011). The Australian professional learning system for primary mathematics teachers therefore plays an important role in developing teachers' knowledge, skills, beliefs and confidence. In the context of this study, a professional learning system refers to the amalgamation of professional learning opportunities available to teachers. These opportunities include, but are not limited to: the professional and staff development sessions that take place at school or off-site; conferences; workshops; online or on campus training or study; academic reading; and access to relevant communities of practice or inquiry.

Professional learning for teachers of mathematics is particularly important, as competency in the subject of mathematics is necessary for student learning beyond the mathematics classroom, and for life beyond school (Milton, Reeves, & Spencer, 2007). The Strategic Plan for WA public schools 2016-2019 had "high expectations of success for every student in every school" (Department of Education, 2015, p. 5) and included targets for raising student achievement in mathematics. Teachers throughout Australia have access to results from the annual National Assessment Program – Literacy and Numeracy (NAPLAN) and can therefore gauge the achievement of their students compared to those nationally and from "similar socio-educational backgrounds" (Australian Curriculum, Assessment and Reporting Authority, n.d.a).

The Trends in International Mathematics and Science Study (TIMSS), which provides an international comparison of student achievement in mathematics, is conducted every four years with students in Years 4 and 8. In Australia, 30% of Year 4 students performed at or below the low international benchmark in the TIMSS in 2007, 2011 and 2015 (Thomson, Wernert, O'Grady, & Rodrigues, 2017). At the low international benchmark "students have some basic mathematical knowledge", and at the intermediate benchmark "students can apply basic mathematical knowledge in simple situations" (Thomson et al., 2017, p. 12). In comparing TIMSS and NAPLAN data, the intermediate international benchmark is equivalent to the level of proficiency for NAPLAN (Thomson et al., 2017). If the criterion for every child to succeed is for every child to reach a level of proficiency, and the international assessments show significant levels of low achievement for Australian primary school students in mathematics, this situation requires attention. Although the average score of indigenous students, as well as students from remote areas and low socio-economic backgrounds, as measured by the number of books in the home, is lower than that of their non-indigenous, metropolitan counterparts with more books in the home, definitive relationships are not apparent (Thomson et al., 2017). To illustrate, 28% of non-indigenous students, 27% of students from metropolitan areas and 18% of students with many books in the home did not achieve the international benchmark, the standard of proficiency in Australia (Thomson et al., 2017), indicating that this situation requires attention across the board.

1.2 THE RESEARCH PROBLEM

It has been considered that the professional learning system for primary mathematics teaching in some countries, such as Australia, is relatively "fragmented" (Even, 2014, p. 331). Within educational research, the experiences of Australian teachers working within this fragmented system of teacher support and development has not been explored. In addition, there appears to be a lack of consensus as to what constitutes high quality teaching in mathematics (Mason, 2016; Schlesinger & Jentsch, 2016). However, teachers have been given the target of increasing student achievement to the point that every student in every school succeeds (Department of Education, 2015). How success is defined is unclear but, as achievement is monitored through NAPLAN results, it could be assumed that success in mathematics is reaching a level of proficiency or above. Numeracy is an essential skill for life (Australian Curriculum, Assessment and Reporting Authority, n.d.b) and the 2015 TIMSS results reveal that 33% of Year 4 students from Western Australia performed at or below the low international benchmark (Thomson et al., 2017). It is clear that primary school teachers will need support in closing the achievement gap. This study therefore aimed to explore how primary school teachers describe their experience of mathematics education, within the context of phenomenology, to gain insights into teacher experiences as a whole, from an insider's perspective.

1.3 SIGNIFICANCE OF THE STUDY

The exchange of knowledge between teachers and researcher, and back to the education community, has potential research significance by providing pathways for change. Changes have potential economic and societal impact. To elaborate, it is hoped that the insights into teachers' experiences gained through this study will provide a deeper understanding of their role and may open dialogue for teaching practices, which could ultimately be of benefit for student outcomes: in gaining a deeper understanding of mathematics education, as experienced by teachers, this study could inform curriculum development, professional learning providers and policymakers, potentially influencing guidelines or training.

Research has shown that teaching practices have a significant impact on student learning and achievement (Finlayson, 2014; Heyd-Metzuyanim, 2013; Kleinhenz & Ingvarson, 2004) and low mathematical achievement can negatively affect overall learning and opportunities in life (Holmes & Dowker, 2013; Mulligan, 2011; Sherman, Richardson, & Yard, 2009). While mathematics education reform has been underway in a number of countries, including Australia, progress in changing teaching practices has been slow (Muir, Beswick, & Williamson, 2010; Simon, 2013).

Contemporary research has focused on teacher knowledge, beliefs, attitudes, identity or performance (Skott, Van Zoest, & Gellert, 2013). Alternatively, it has sought to identify best practice, providing recommendations, tools and resources for teachers (Hattie, 2017). While valuable, the author's review of the research literature has led to the assertion that the gap in research appears to be in looking at the experience of teaching mathematics in primary schools as a whole, from an insider's perspective.

In line with education reform, the context in which primary school teachers in Australia teach is one of inclusion. Teachers' beliefs and attitudes have been shown to significantly impact the success of inclusive classrooms (Scherer, Beswick, DeBlois, Healy, & Opitz, 2016; Vaz et al., 2015), with such research revealing that teachers do not all hold the same beliefs. Given the important challenge teachers face in recognising that all children can learn mathematics, and in taking responsibility for ensuring all children succeed, this study provides a voice for primary school teachers to address their experience of mathematics education from their perspective. Through this approach, the research generates new understandings. The understanding of teachers' perspectives on mathematics education has research significance as it underpins the advancement of mathematics education.

1.4 RESEARCH QUESTIONS

The overall aim of this research is to explore the lived experience of primary school mathematics teachers in Western Australia. To guide the study, the main research question is:

1. How do primary school teachers perceive and experience mathematics education?

To ensure the research provides insight into relevant contextual factors, the research also considers:

2. How do primary school teachers perceive their experiences of mathematics education to have changed during their career?

1.5 THESIS OUTLINE

Chapter One has briefly illuminated the context in which primary school teachers work. The current results in Australian mathematics education - when subjected to international comparisons - as well as an identified gap in mathematics education research, are also highlighted. These results and the identified gap in the research on mathematics education provided motivation for this study and contribute to the significance of the research undertaken. The significance of the study and specific research questions to be addressed are explained in further detail, along with this overview of the thesis itself.

Chapter Two provides a conceptual framework and review of the professional and research literature relevant to the phenomenon of mathematics education in Australian primary schools. It begins by setting the scene, before focussing on current research literature into: the teaching and learning of mathematics; student diversity; teachers of mathematics; and the measuring and reporting of student achievement in mathematics.

Chapter Three explains the research design by outlining the theoretical framework, methodology and method used for this research project. The section on methods considers data collection, participants, quality of data and ethics. An illustration of the data analysis process is also provided.

Chapter Four presents the research findings. A narrative on how primary school teachers perceive and experience mathematics education is given, supported by quotes from the interviews.

Chapter Five discusses the findings, and highlights relationships between the findings and current literature on mathematics education.

Chapter Six presents the conclusions of this research study. The limitations of this research project are acknowledged, conclusions are linked to the research questions, and recommendations for key stakeholders in mathematics education are offered.

Chapter 2: Review of the Professional and Research Literature on Mathematics Education

To explore the phenomenon of mathematics education from the perspective of primary school teachers, it is first necessary to examine the professional and research literature on teaching and learning mathematics. Research into mathematics education varies in its focus. For example, the various foci include: knowledge and beliefs; mathematics learning difficulties and affective influences, such as mathematics anxiety; specific teaching practices, such as the use of manipulatives and representations; and specific topics, such as fractions. This literature review provides a description of the context within which primary school mathematics teachers work, and focuses on the areas of mathematics education research that have greatest relevance to the lived experiences of primary school teachers, as revealed by this research study.

The literature review therefore begins by setting the scene, exploring various developments in understanding of how children learn, along with changes in recommended teaching approaches, both of which have impacted what is expected of primary school mathematics teachers. Then a snapshot of mathematics in society today and an exploration of current research into the teaching and learning of mathematics is presented. Moving from the subject of mathematics to the students and teachers involved in mathematics education, the diversity of student needs is reviewed, followed by teachers' knowledge, beliefs and development. Finally, the measurement and reporting of student achievement in mathematics is considered. The review of the literature describes notable theories and approaches, identifies controversies, and defines key terms. The purpose of the review of the professional and research literature on mathematics education is to examine the current state of knowledge and reveal the gap in research that this study addresses, demonstrating why the study is both timely and relevant.

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2.1 TEACHING PRIMARY SCHOOL MATHEMATICS: A CHANGING SCENE

This section of the review provides background to the context in which the teaching and learning of mathematics takes place today.

Historically, there are many key people whose work has increased understanding of how children learn mathematics. For example, in the late 1700s Pestalozzi advocated giving children opportunities to form accurate observations through physical activity with concrete objects, and "moving from the simple to the complex, from the concrete to the abstract, in both mathematical symbols and language" (Kramer, 1978, p. 65). In the 1800s Froebel developed many materials and was a strong advocate for early childhood education (Froebel & Lilley, 1967), and in the late 1800s and early 1900s Montessori used sensorial materials, advocated matching and sorting activities, broke down skills into small steps, and recognised the importance of hands-on experiences (Montessori, 1964). Montessori developed many materials to prepare children's minds for mathematical discussions, believing that children develop and gain knowledge through inner activity, constructing meaning from their own experiences through their own efforts (Montessori, 2012). Piaget's experiments supported the view of children acting from intrinsic motivation, active in their learning and adapting to their environment through 'assimilation and accommodation' (Piaget, Gruber, & Vonèche, 1977), and it is the perspective that people construct knowledge through their interpretation of experiences, rather than simply absorbing it, that is known as 'constructivism' (McDevitt & Ormrod, 2013, p. 196).

The notion of constructivism, as well as Piaget's stages of cognitive development, prompted significant changes in mainstream education, guiding teachers on how to teach and what to expect from students at different ages (McDevitt & Ormrod, 2013). Furthermore, Vygotsky developed sociocultural theory, emphasising the role adults take in conveying their cultural interpretation of the world to children, as well as the relationship between thought and language, with his influence on education seen in teachers working within a child's 'zone of proximal development' and scaffolding their learning (Cole, Daniels, Vygotsky, & Wertsch, 2007; McDevitt & Ormrod, 2013).

Since the 1950s, several constructivist approaches have emerged under different names, such as discovery learning, problem-based learning and inquiry learning (Kirschner, Sweller & Clark, 2006; Kuhn, 2007). However, since the introduction of discovery learning more has been learnt about working memory and long-term memory in the context of learning, and it has been asserted that the demands placed on working memory during a problem-based learning situation is so great that the opportunity to learn is impaired (Kirschner et al., 2006). After ongoing debates on whether teachers should provide explicit, direct instruction or use constructivist approaches, it became apparent that “there is a place for both” (Kuhn, 2007, p. 112; J. E. Cole & Wasburn-Moses, 2010), that methods should be chosen in line with specific learning goals, and that “the challenge is to get the balance and sequence right” (Kuhn, 2007, p. 112).

Direct instruction involves full explanation of concepts, procedures and strategies (Kirschner et al., 2006), applying these in various contexts, and “structured verbal exchanges between students and teachers” (Flores & Kaylor, 2007, p. 86). Many differences between direct instruction and constructivist approaches have been identified, including: the emphasis placed on discussions and group work; how topics and tasks are sequenced; and the use of representations and feedback (Munter, Stein & Smith, 2015).

Direct instruction was initially used more often in the context of special education (J. E. Cole & Wasburn-Moses, 2010), but has since been proven effective and efficient in both general and special education settings (Flores & Kaylor, 2007). In the current context of inclusive education, while instructional approaches can vary from direct to dialogic, recent recommendations indicate that a teacher should not exclusively use one or the other but choose the best approach for each specific task at hand (Hattie, 2017, p. 24).

It is beyond the scope of the literature review to provide more than this brief summary of a portion of the research that has influenced changes in education but it is sufficient for the purpose of exemplifying how mathematics teaching, traditionally characterised by rote learning, has evolved into something much more complex, now requiring teachers to be cognisant of child development and to develop specific pedagogical content knowledge (PCK). PCK is the combination of subject content knowledge, knowledge of students, and teaching practice knowledge, that influences choices teachers make in how to present topics to their particular students (Shulman, 1987).

Changes in recommended teaching approaches are associated with education reform. Reform in this context can be regarded as changes that are made, or attempted, in order to improve education. To be effective, reform agendas need to be feasible and clearly communicated so that teachers understand implications for practice (R. Evans, 1996). However, it has been asserted that teachers are rarely given the opportunity to explore innovations meaningfully and that new information may therefore contribute to teacher knowledge but have a fairly small influence on their beliefs or their actions (R. Evans, 1996). Superficial levels of understanding can mean that only small changes are made and so although an innovation may not be fully implemented, it is perceived as a failure, fuelling the continual search for solutions to the same persistent problems (R. Evans, 1996).

2.2 MATHEMATICS IN SOCIETY TODAY

Mathematics education has been highlighted in Australian government papers as a priority in response to changes in Australian economics, with increasing demands for skilled rather than unskilled workers (Geeves, 2014). Consequently, it is increasingly important for all students to acquire mathematical skills, and it is recognised that students' early educational experiences bear great significance on their later learning and life (Batchelor, Torbeyns, & Verschaffel, 2019; Geeves, 2014).

Furthermore, there is an increasing focus on and demand for science, technology, engineering and mathematics (STEM) subjects, deemed essential to manage "the complex problems facing the world" (Timms, Moyle, Weldon, & Mitchell, 2018, p. 3), but there has been a drop in the number of students choosing to study these subjects in higher secondary school years (Timms et al., 2018, p. 4). In response, the Australian government approved a National STEM School Education Strategy 2016 – 2026, the main aims of which are "to ensure all students finish school with strong foundational knowledge in STEM and related skills" and to stimulate student interest in STEM subjects (Timms et al., 2018, p. 5). In designing strategies to meet these aims, concerns over the number of teachers qualified in this area, as well as the suitability and quality of the STEM curriculum, are being addressed (Timms et al., 2018, p. 9). Stemming from their review of recent literature, Chalmers, Carter, Cooper and Nason (2017) observed that "designing integrated STEM curriculum units that facilitate in-depth learning of and about STEM is challenging" (p. 26).

In considering the curriculum, it has been asserted that national testing and "the current obsession with international comparisons" influences curriculum (Brown, 2016, p. 79), reducing opportunities to nurture personal connections to mathematics, along with creativity in mathematical thought and the application of school mathematics, by encouraging a focus on skills that can be easily tested (Brown, 2016, p. 82). The various perspectives of different stakeholders in education regarding the aims of the curriculum can also lead to a disconnect between the original ideas and intentions of policymakers and how the curriculum is used by teachers (Brown, 2016, p. 80).

High-stakes testing, such as NAPLAN, was introduced with the aim of: assisting teachers in determining which areas of the curriculum to focus on improving; and recognising which individual students need support (Polesel, Rice, & Dulfer, 2014, p. 652). However, the use of NAPLAN results has led to comparisons being made between schools, made possible by the public availability of results such as on the MySchools website (Polesel et al., 2014, p. 652). These public assessments have resulted in schools and teachers feeling an increased pressure to perform, which has commonly led to changes in teaching approaches in preparation for NAPLAN, as well as alterations in the range of content taught, as teachers endeavour to positively influence scores (Cranley, 2018, p. 30; Polesel et al., 2014, p. 652). Many teachers do additional work and spend valuable lesson time to prepare their students for the tests (Dulfer, Polesal, & Rice, 2012). Providing students with practice tests and guidance in test-taking strategies is particularly common (Cranley, 2018, p. 80). Research suggests that teachers feel conflicted, discontent with the changes they feel they have to make, and concerned over the impact NAPLAN testing has on their teaching and the consequent experience of their students (Polesel et al., 2014, p. 653). Cranley's research (2018) indicated that the level of anxiety experienced by students can depend on the emphasis their teacher places on the testing, and even where a school may attempt to minimise the pressure for students, students can still feel uncomfortable with the test conditions, such as time constraints, the different layout of the classroom, and working individually in silence.

Teachers can find NAPLAN results useful, with the negative consequences of testing occurring due to the pressures felt - a product of how results are used beyond the classroom (Polesel et al., 2014, p. 653). Research has found that the teachers of students in the year before NAPLAN testing are likely to experience the most pressure, as they perceive the results to be a reflection of their teaching (Cranley, 2018). It has been suggested that accountability and testing "regimes" are the reason that the "wonder of mathematics is often lost in schools" (Brown, 2016, p. 76).

It is apparent that the focus on mathematics in society today has a significant influence over the context in which teachers work, and therefore teachers' experiences of mathematics education. With these factors directly impacting choices in teaching approaches, and with an abundance of research confirming that "high quality teaching" is the strongest influence on student engagement and achievement in mathematics (Geeves, 2014, p. 16), it is important for all teachers of mathematics to understand what high-quality teaching entails.

2.3 CURRENT RESEARCH INTO THE TEACHING AND LEARNING OF MATHEMATICS

Building on the ideas of constructivist and socio-cultural theories, there has been an abundance of research into learning trajectories, as well as research examining in fine detail the discourse, feedback, even gestures, that take place in the classroom. There is a sense of an increasing appreciation of the nature of mathematics, along with a growing understanding of the challenges encountered in the complex process of learning mathematics. As such, the latest recommendations for teaching mathematics include strategies that relate to instructional approaches, learning intentions and different 'levels' of learning, how to identify and respond to individual student needs, the importance of discourse, and teacher-student relationships.

2.3.1 Structuring and scaffolding learning in mathematics

To provide guidance in the complex process of teaching and learning mathematics, hypothetical learning trajectories describe an appropriate sequence of activities to support students along their natural path of development. Trajectories are hypothetical because the anticipated path planned by the teacher may change as interactions, and the teacher's observations of student learning, influence what is actually required during the teaching and learning process (Simon, 1995). The hypothetical learning trajectories model aimed to provide teachers with guidance on how to implement constructivist principles in teaching mathematics (Yackel, Gravemeijer, & Sfard, 2011). Identifying appropriate sequences in mathematics instruction enables a teacher to identify pre-requisite knowledge required by students for the topic taught, to know how to extend learning, and to appreciate the relevance of what is being learnt as a foundation for future learning. However, using learning trajectories to plan set sequences for collective groups of students has been criticised as unresponsive to the individual needs of students and not reflective of the intended use of the model (Yackel et al., 2011), bringing into question the suitability of a 'one size fits all' curriculum if it is strictly adhered to rather than used flexibly:

> Individuals respond differently to the teacher's directions, have different prior knowledge, construct different understandings, and propose different problem representations and strategies. They bear distinct and changing mathematical conceptions and misconceptions, and engage differently with ideas proposed by others. (Goldin, Epstein, Schorr, & Warner, 2011, p. 547)

Mathematics, constructed by humans through thinking about thinking, has many layers. With arguments generally established through prior reasoning, these often depend on one or more other arguments. As such, "cycles of expansion followed by compression bring about the accumulation of one discursive layer upon another … Created and objectified, new discourse is said to subsume those in which it originated" (Sfard, 2008, p. 124). Therefore, once mathematical ideas have been grasped and procedures learnt, the more layers there are supporting that, the harder it may be for someone to describe their actions, just as it may be hard for a centipede to describe how he coordinates his legs (Sfard, 2008). As the hierarchical structure is complex, the analogy of a tree is used to depict how ideas interconnect and relate, as opposed to a chain, "which would indicate a more linear process" (Sfard, 2008, p. 166). Often, understanding what one mathematical term or symbol stands for is necessary for understanding other ones, which means that while some students may be engaged in a positive "cycle of participation" others may be in a vicious cycle –

unable to join in because, while a certain level of experience and understanding is necessary to be able to take part, this pre-requisite understanding is gained through participation (Sfard, 2008, p. 161).

To facilitate the learning of individual mathematical concepts, teachers often scaffold learning by providing multi-modal representations. Understanding is developed from reference to concrete materials then visual representations, enabling students to then grasp abstract ideas. Research supports this approach, revealing that a concrete-representational-abstract approach promotes considerable "gains in mathematics learning" (Hattie, 2017, p. 170) and using multiple representations leads to deep learning (Hattie, 2017, p. 169). Sfard (2008) highlights the role of discourse in the construction of concepts, including an examination of the relationship between concrete and abstract objects. As learning the specific correlation between words and concepts "within a mathematics context" is a significant part of learning mathematics (Boaler, 2000, p. 205), the complexities in conveying and understanding mathematical concepts will be explored in more detail.

2.3.2 The complexities in conveying and understanding mathematical concepts

To share their own mathematical knowledge and enable students to participate in mathematics learning, teachers need to help students understand the language of mathematics, as well as the content (Boaler, 2000, p. 202). Mathematics has been described as a language, though Boaler (2000) prefers to consider mathematics as a register, given its grammatical structure, specialised vocabulary and lexical density (Boaler, 2000, p. 202). In terms of grammar the structure of a mathematical sentence can be altered, in turn altering the complexity of the task. For example, the information can be structured to ask for the total of two quantities when added together, or it may give one addend with the total and ask for the missing addend (Boaler, 2000, p. 206). Specialised vocabulary refers to the words and symbols that are unique to mathematics and will be new to learners of mathematics – such as circumference, denominator and rhombus, as well as words that have specific meanings in mathematics but a different meaning in everyday contexts – such as difference, plot and table (Boaler, 2000, p. 205; Hattie, 2017, p. 50). Lexical density refers to the density of words or symbols bearing significant information, and mathematical sentences are typically both brief and precise, with each element specific and necessary.

Given that languages, and register, describe objects that already exist, Sfard (2008) prefers to consider mathematics as discourse. Sfard (2008) distinguishes mathematics from other subjects, asserting that "*mathematics begins where the tangible real-life objects end and where reflection on our own discourse about these objects begins* [italics in original]" (p. 129). Mathematical concepts can therefore be represented but never really shown, so metaphors are often used to aid understanding of these abstract ideas, with "concrete concepts" used to describe "abstract concepts" (Lakoff & Núñez, 2000, p. 39). Unfortunately, using metaphors can lead to students developing misconceptions, as metaphors have been compared to "Trojan horses … with hidden armies of unhelpful entailments" (Sfard, 2008, p. 35).

Whether considering mathematical talk from the perspective of a language, register or discourse, students must "de-code teacher-talk" (Boaler, 2000, p. 203). This task involves students decoding both the words and symbols used, with the difficulty of the task increased by lexical density and made more complex when given in a particular context (Boaler, 2000, p. 209). In presenting mathematical problems in a particular context, assumptions have been made about the students' socio-economic or cultural background. There may be some students who can relate to the question and others who cannot, impacting their potential for success (Boaler, 2000, p. 216).

2.3.3 Recommended teaching approaches from a synthesis of research

It has been suggested that when a situation occurs where there are some students who can and others who cannot do mathematics, this is because of the way mathematics is taught, not due to the nature of the subject itself (Brown, 2016, p. 76). To enable students to succeed, the latest recommendations for teaching mathematics include strategies that relate to instructional approaches, learning intentions and different 'levels' of learning, how to know and respond to individual student needs, the importance of discourse, and teacher-student relationships.

Mathematics teaching requires instruction, demonstrations, explanations and illustrations to be made, and it has been found that effective teachers are likely to have connectionist, rather than transmission or discovery orientations (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997; Geeves, 2014, p. 18). A connectionist orientation involves explicitly making links between current and previous work, putting tasks into context, exploring connections between different methods for solving problems, and highlighting connections between different areas of the mathematics curriculum (Askew et al., 1997). In accordance with a connectionist orientation, when looking specifically for effective teaching strategies for students with mathematics anxiety, Finlayson (2014) identified approaches such as: connecting new knowledge to existing knowledge; progressing from easy to more difficult tasks; and providing numerous opportunities to practice and ask questions.

To implement these instructional approaches requires teachers to structure lessons appropriately, an attribute of effective teaching identified by Sullivan and the Australian Council for Educational Research (2011), who also advocate for clearly communicating learning goals to students in mathematics. One commonly recommended element of the structure of mathematics lessons, to communicate mathematical ideas, is to use various representations (Hattie, 2017), and to teach using manipulatives (Boaler, 2000). Boaler and Dweck (2015) also recommend encouraging students to be creative by making conjectures or creating their own visual representations, and through using "intuition and freedom of thought" (p. 188) to solve problems before being taught how to solve the problem. It is recommended to teach for conceptual understanding (Geeves, 2014), and to help the development of both fluency and transfer (Hattie, 2017; Sullivan & Australian Council for Educational Research, 2011).

Within mathematics education, different levels of learning can be achieved. *Surface* learning occurs first and is essential, as it represents beginning to understand concepts, skills and vocabulary (Hattie, 2017). *Deep* learning occurs when students start to see connections between concepts and develop fluency through continued use of the skills and knowledge acquired. Through experience, investigations and developing conceptual understanding, deep learning can enable students to then *transfer* their knowledge and skills, applying these in different contexts (Hattie, 2017, p. 8). In relation to levels of learning, mathematical tasks can vary in their difficulty and complexity, so the demands of a task chosen by the teacher needs to be considered as part of planning learning intentions and success criteria (Hattie, 2017,

p. 82). Tasks low in both difficulty and complexity are useful for developing fluency, difficult tasks require stamina and can help develop perseverance, and complex tasks promote strategic thinking (Hattie, 2017, p. 77). Developing automaticity is important to ease the cognitive load, enabling students to more easily perform multi-step and complex tasks (Westwood, 2011), and surface learning must take place before deep learning can occur. While both automaticity and surface learning are essential, it has been asserted that too much teaching time is spent on lower level tasks, without connections (Hattie, 2017, p. 82) and that "too often, learning ends at a surface level" (Hattie, 2017, p. 131). Deep and transfer learning are important for later learning and life because:

> If you learn something deeply, the synaptic activity will create lasting connections in your brain, forming structural pathways, but if you visit an idea only once or in a superficial way, the synaptic connections can "wash away" like pathways made in the sand. (Boaler & Dweck, 2015, p. 1)

The curriculum gives some guidance to teachers but, as learning in mathematics does not always take place in a linear and predictable way, it is not in perfect alignment with each individual student's learning needs. For example, within each class, some students will have already mastered specific learning goals and others will require a great deal of scaffolding to achieve the same goals (Hattie, 2017, p. 16). Preassessments, otherwise termed diagnostic testing, can help inform teachers of their students' instructional needs, allowing teachers to have realistic expectations of their students (Hattie, 2017, p. 40). In mathematics, teachers are prone to overestimate what students will achieve (Hattie, 2017, p. 40). This tendency to overestimate what will be achieved relates to the hierarchical structure of mathematics, making it difficult for one with expert knowledge to describe and break down all of the supporting layers, and leading to a situation where a teacher "fails to recognise the fits and starts of students as they attempt to learn new concepts" (Hattie, 2017, p. 41).

Once student needs have been identified, differentiation is seen as important: it has been asserted that effective mathematics teachers challenge all students (Geeves, 2014, p. 19) and that effective teaching involves differentiating challenges (Sullivan & Australian Council for Educational Research, 2011, p. 24). Differentiation can be achieved by: altering the content of what is being taught; keeping the content the same but providing different resources or representations to alter the strategy that will used; or giving different tasks so that students are required to show their understanding of the content in different ways (Hattie, 2017, p. 213). However, with their focus on equity in mathematics education, there are researchers who have questioned the effectiveness of differentiation. Anthony, Hunter and Hunter (2019) have asked whether more difference might result from responding to the diversity of student needs in this way. Some researchers, such as Prast, Weijer-Bergsma, Kroesbergen and Van Luit (2015), have advocated using explicit instruction for low-attaining students and “exploratory instruction” (p. 99) for high-attaining students, but Anthony et al. have asserted that there are limited studies on achievement gains made through the implementation of differentiation models, and they have therefore questioned the appropriateness of this kind of differentiation model. Offering a critique of differentiated instruction, it has been asserted that: models based on student readiness deliberately delay teaching, and therefore have the potential to increase the achievement gap; and there is risk in ability grouping due to the impact on teacher expectations of students, when students are seen as low-attaining or high attaining (Anthony et al., 2019).

Boaler and Dweck (2015) suggest differentiating by providing ‘low floor, high ceiling’ tasks that can be represented in various ways and solved using a variety of strategies. These tasks are typically open ended. Boaler and Dweck (2015, p. 117) also suggest providing options regarding which task to complete, with the emphasis being on enabling students to take responsibility for this choice, rather than each of the tasks on offer being assigned to specific students. Furthermore, Boaler and Dweck (2015) warn against ability grouping due to the positive correlation that has been found to exist between the extent of ability grouping and the range in student abilities, coupled with findings that equitable achievement among students is evident where all students have had access to “high-level content” (p. 112). Likewise, research findings show that effective teachers hold “high expectations of initially low-attaining students” (Council of Australian Governments, 2008, p. 29).

Giving all students an opportunity to learn the same content is conducive to classroom discourse, with students learning a great deal from listening to each other’s understandings, strategies and explanations. The importance of discourse is increasingly recognised in both research and professional literature. Hattie (2017) explains how classroom discussions can be used to: build understanding and confidence; make connections; examine and clarify ideas; justify and reason; and to explore alternative approaches. To support productive and inclusive discussions, the classroom should be experienced as a safe place by students, where mistakes are valued and learnt from, and perseverance is nurtured as students attempt to make sense of mathematical ideas and find solutions to problems (Hattie, 2017). When students are encouraged to reflect on their own thinking, this metacognition supports all levels of learning, therefore discussions should be both purposeful and planned for (Hattie, 2017). However, while the current influence of constructivism on syllabi and professional learning places a focus on collaborative learning, Evans (2007) argues that this approach is ineffective for children with learning difficulties.

Given that “students do not just learn mathematics in school classrooms, they learn to *be*” (Boaler, 2000, p. 188), student-teacher relationships are also discussed in the literature. In addition to recommendations to make the classroom feel safe for students, there are recommendations to promote positive attitudes (Geeves, 2014, p. 19) and to foster engagement (Sullivan & Australian Council for Educational Research, 2011). Boaler and Dweck (2015) specifically address student mindset in their work, describing the teacher’s role in encouraging and believing in all students; and they advocate giving praise and support in such a way as to foster student beliefs about neuroplasticity, in particular that effort improves intelligence. Student-teacher relationships are further referred to throughout the following section, in which the students of mathematics, in particular the nature and impact of student diversity, is examined in more detail.

2.4 STUDENT DIVERSITY

In line with recommended teaching approaches, within Western Australian primary school classrooms of today, mathematics education involves opportunities for students to engage in both individual and collaborative work. Students, with their diverse range of existing knowledge and beliefs, are challenged to construct new understandings and apply mathematical knowledge in problem solving contexts:

> As individual students share ideas, there occur wrong answers, blind alleys, and fruitful suggestions. In such situations, students often disagree and

> criticize each others' ideas. Social interactions may evoke strong emotional feelings, leading sometimes to deeper engagement and other times to disaffection. (Goldin et al., 2011, p. 547)

As such, the recommended teaching approaches stem not only from the nature of mathematics, but also from the reactions of students to mathematics, and the importance of teacher-student and student-student relationships. In common with many school subjects, there is a wide range of student abilities in mathematics. The impact of this student diversity on the experience of mathematics and literacy for teachers and students, in comparison to other primary school subjects, is somewhat unique due to the importance placed on these subjects and associated achievement goals. The subject of mathematics, in particular, often elicits strong emotions (Batchelor et al., 2019). The wide range of student abilities in mathematics, and affective variables, are therefore significant factors in the experience of mathematics education, for both teachers and students.

2.4.1 The wide range of student abilities in mathematics

In exploring the variety of student reactions to the same mathematics teaching, it has been asserted that:

> Affective/social interactions occur, students grapple with the underlying problem structures that involve additive, multiplicative or recursive processes. Their cognitions vary widely. Individuals respond differently to the teacher's directions, have different prior knowledge, construct different understandings, and propose different problem representations and strategies. They bear distinct and changing mathematical conceptions and misconceptions, and engage differently with ideas proposed by others. (Goldin et al., 2011, p. 547)

Many teachers therefore cater for a wide range of student responses to, and abilities in, mathematics. However, there has been less research into mathematics learning difficulties in comparison to literacy (McLeskey & Waldron, 2007; Van Steenbrugge, Valcke, & Desoete, 2010), so there are fewer intervention programs available to support teachers (Mulligan, 2011). While research into effectiveness of intervention programs indicates that all children can learn mathematics (Council of Australian Governments, 2008; Holmes & Dowker, 2013; Mulligan, 2011; Sullivan

& Gunningham, 2011) and this message is clearly conveyed to teachers through documents, such as First Steps in Mathematics (Department of Education, 2013, p. 3), mathematics learning difficulties are challenging to diagnose (Kucian & von Aster, 2015) and interventions are complex (Gersten et al., 2009). There is not one single remedial approach or tool that will be effective in every circumstance (Gifford & Rockliffe, 2012).

To exemplify, findings indicate that a typical child learns to differentiate and link numerical representations, such as digits, number words and magnitude, with experience and maturation of neurological processes; number processing also requires cognitive skills such as counting and arithmetic, magnitude comparison, working memory and attention; children with developmental dyscalculia exhibit a diversity of individual strengths and weaknesses in these cognitive skills and it is the lack of homogeneous characteristics that makes the definition and diagnosis of developmental dyscalculia challenging (Kucian & von Aster, 2015). Experts in special education, neurology, psychiatry and behavioural sciences, Luculano et al. (2015) found normalisation of brain activity patterns as a result of their intervention study using the MathWise program, as well as increased performance with brain normalisation. Similarly, Kucian and von Aster (2015) obtained results indicating neuroplasticity and neural normalisation following their intervention study in which students used a specially designed computer program, Calcularis. Although these studies provide evidence that all children can learn, they worked with individual students or small groups of two, highlighting the need for more research into successful interventions that are inclusive.

Interventions in mathematics commonly involve leaving the classroom to work with a support teacher (Gersten et al., 2009). Leaving the classroom can be a stigmatising experience, and a fragmented schedule can make learning and teaching more difficult (McLeskey & Waldron, 2007, p. 165). McLeskey and Waldron (2007) highlight the availability of inclusive options, such as co-teaching, smaller class sizes, grouping differently, modifying the curriculum, and peer tutoring, suggesting the least obtrusive options should be chosen to fit with the existing teaching environment. These suggestions take into consideration a student’s affective domain.

2.4.2 Affective variables

The affective domain encompasses variables such as emotions, attitudes, beliefs and values (Beltrán-Pellicer & Godino, 2019). Mathematics-related affect has also been described as including "motivations towards mathematics" (Batchelor et al., 2019, p. 201). Affective factors are sometimes referred to as affective variables because they are changeable in intensity, as well as in how they show themselves, and in their presence (Beltrán-Pellicer & Godino, 2019). They are not always easily seen or interpreted, especially in a classroom environment where the teacher cannot physically see all student gestures all of the time (Beltrán-Pellicer & Godino, 2019, p. 5). Even when an emotion is displayed, witnessed and interpreted during a mathematics lesson, the emotion may not have arisen from the mathematics, but from other contextual factors (Beltrán-Pellicer & Godino, 2019), making correct responding challenging.

Related to context, what emotions signify is variable: feeling ‘‘good’’ can indicate positive engagement and interest, or it may be the result of finding work easy; finding a lesson ‘‘fun’’ could signify enjoyable learning activities or "diverting social interactions"; and ‘‘frustration’’ can be experienced when progress in problem solving or grasping understanding is temporarily at a standstill, but in this case is a positive emotion signifying "enhanced interest" and "serious engagement", or frustration may be experienced negatively when associated with "anticipation of failure" (Goldin et al., 2011, p. 551). However, as learning depends not only on cognitive factors but also on affective factors, the affective domain is important in educational settings (Batchelor et al., 2019; Schukajlow, Rakoczy, & Pekrun, 2017). Motivation and emotions are necessary for learning to take place; they are an influential factor during learning, and a consequence of learning (Schukajlow et al., 2017, p. 307). It is therefore important to understand the affective domain as much as possible, and related implications for teaching and learning.

Emotions, or feelings, are complex, having "affective, cognitive, psychological, motivational and expressive components" (Schukajlow et al., 2017, p. 309). Emotions represent attitudes, beliefs and values; in turn, attitudes, beliefs and values are either strengthened or altered by enduring emotions (Beltrán-Pellicer & Godino, 2019). For example, if students experience boredom or anxiety during a mathematics lesson once, they are simply in a state of boredom or anxiety on that occasion, but if they feel bored or anxious often in mathematics lessons, then this state could become a trait; consequently, even thinking about mathematics may then cause boredom or anxiety (Schukajlow et al., 2017, p. 309). Similarly, if students' interests are aroused by mathematical tasks often enough, this can result in them having a general interest in the subject; student emotions in mathematics can therefore be interconnected with their learning experiences and learning outcomes through either positive or negative cycles (Schukajlow et al., 2017, p. 310).

There are many aspects of the mathematics classroom environment that can trigger student emotions, such as: how the mathematics is taught; whether the student perceives what is expected of them to be achievable and reasonable; how goals are presented; social interactions that take place and related expectations; feedback received; and "consequences of achievement" (Schukajlow et al., 2017, p. 312). For example, if students perceive a task to be unachievable and/or unreasonably demanding, this impacts their sense of control, which consequently impacts their emotional state, with research finding that "perceived excessive demands were … positively related to anxiety, anger, helplessness, and boredom" (Schukajlow et al., 2017, p. 312).

Neurologically, as different areas of the brain – such as the prefrontal cortex, amygdala and ventral striatum – mature at different rates, children can find it more difficult than adults to regulate their emotions (Martin & Ochsner, 2016). Within education, in relation to pitching learning goals in accordance with student abilities, if students have negative "expectations of success" but perceive success in mathematics to be important, they are likely to worry about mathematics (Schukajlow et al., 2017, p. 312). Conversely, when students' needs for control and "social relatedness" are met, they experience positive emotions that can contribute to both their motivation towards mathematics and their comprehension of the mathematics being taught, leading to positive learning outcomes (Schukajlow et al., 2017, p. 310).

Attitudes are more stable than emotions, and have both affective and cognitive components (Beltrán-Pellicer & Godino, 2019). Particularly relevant to the learning of mathematics, students vary in how curious, sceptical and flexible they are (Beltrán-Pellicer & Godino, 2019). A student's attitudes, emotions and motivations towards mathematics intersect with their beliefs but, with a sizeable cognitive component, beliefs are more stable than emotions and attitudes (Beltrán-Pellicer & Godino, 2019).

Within mathematics education, different student beliefs have been identified: beliefs about the teacher's expectations of them and beliefs about the teaching of mathematics; beliefs about the subject of mathematics; beliefs about themselves as students of mathematics; beliefs about the context in which they learn mathematics, such as the classroom environment, relationships with and perceptions of other students in the class, as well as school and parental expectations (Batchelor et al., 2019; Beltrán-Pellicer & Godino, 2019; Goldin et al., 2011). These beliefs have been found to affect student "interactions, problem solving, and in-the-moment engagement" (Goldin et al., 2011, p. 548).

Engagement has many components, including motivation towards mathematics, beliefs and emotions, and has been described as "a behavioural / affective / social constellation" (Goldin et al., 2011, p. 549) situated in the person "moment-by-moment", rather than a trait (G. Lewis, 2013, p. 74). Student engagement and motivation can therefore change during a lesson in response to contextual factors, including feedback received (Goldin et al., 2011; Schukajlow et al., 2017). Student engagement is of interest to teachers as research indicates positive correlations between student engagement and both achievement in mathematics and growth in mathematics learning (Goldin et al., 2011). It has also been asserted by Pais that although some students may engage in mathematics due to a genuine interest in learning, other students are influenced by teachers and parents, as their level of engagement stems from a desire to meet expectations:

> A will to satisfy some Other's demand (say, parents' demand for good grades, teachers' demand for learning, academic or professional demands, etc.). It is an aspiration as pious as it is naive to assume that students will engage in mathematics for the satisfaction of exploring mathematics. (as cited in Brown, 2016, p. 82)

Investigating educational experiences, Finlayson (2014) purports that external factors, such as teaching approaches, cause anxiety rather than the subject itself. Aspects of a traditional teaching approach reported to have caused mathematics anxiety include an emphasis on tests and a focus on learning set methods to get correct answers, with little time spent on understanding the process (Finlayson, 2014). It is also suggested that parents and teachers who experience mathematics anxiety themselves may pass this on to the children in their care (Finlayson, 2014). In an educational setting, students may feel anxious about doing their work due to a fear of failure. Fear is the cognitive component of assessing whether something is a threat, while anxiety is the emotional response to encountering what is feared (Kolacinski, 2003, p. 14). Initially, a response to failure might be to try harder; or, the person might engage in a pattern of avoidance (Crozier, 1997, p. 136). Anxiety can be debilitative, interfering with cognitive processes such as working memory and attention, reducing confidence and self-efficacy (Ashcraft & Krause, 2007, p. 247).

Causes of anxiety in a classroom may include embarrassment due to “lower-than-average” abilities or repeated failures: once established, attitudes such as believing that how hard you try will not make a difference - the work is just hard and you are either good at it or you are not - can fuel the continuation of mathematics anxiety (Ashcraft & Krause, 2007, p. 247). The student’s self-efficacy or anxiety can then determine success more so than the mathematical tasks themselves (Kolacinski, 2003, p. 17). High-stakes testing has also been found to cause anxiety or self-esteem issues (Cranley, 2018). For young students, in Years Three and Four, anxiety has been attributed to the formal arrangement of desks for test conditions, which are unusual to this age group (Cranley, 2018), and focusing on the results can lead to “premature labelling” and a negative cycle in terms of self-esteem and achievement (Cranley, 2018, p. 27).

Student self-efficacy beliefs are a strong indicator of success in mathematics (Council of Australian Governments, 2008) and learning difficulties that occur as a result of low self-efficacy are not difficulties a child is born with, they come about through the child’s educational experience. Some students with a fixed mindset may develop learned helplessness, a situation in which they do not feel in control of their learning outcomes and may therefore perceive success as luck rather than attributing it to themselves: such low self-efficacy can lead them to believe that they will never succeed at school (S. Yates, 2009). Some research suggests that “learned helplessness behaviour patterns may develop over long periods of time, leading to a student’s displaying a lack of motivation and persistence even when exposed to effective academic instruction consisting of appropriate task requests and reinforcement for correct responding” (Sutherland & Singh, 2004, p. 171).

Contrastingly, other research indicates the possibility of positive change with changes in teaching approaches or teachers, finding that favourable shifts in teacher-student relationships can positively influence "affect towards mathematics" (G. Lewis, 2013, p. 81). This issue emphasises the importance of sensitivity to a student's emotional needs, and demonstrates why teacher knowledge and confidence is critical to a successful learning environment. It also highlights the importance of relationships in teaching, which are harder to assess or measure (S. J. Ball, 2003).

Relatively recent research on fixed and growth mindset - believing in either innate abilities (fixed mindset) or effort (growth mindset) as determinants of success - has produced conflicting results. While the original studies reported by Dweck in 2006 indicated positive gains, schools have failed to replicate these results (Bloom, 2017). Reasons for this have been suggested, such as teachers misunderstanding the original intentions and main messages of Dweck's work, leading to flawed implementation (Bloom, 2017). It is possibly in reaction to the abundance of research on affect in mathematics that teachers aim for students to experience mathematics lessons positively - the danger of this reaction is that students are unnecessarily protected from beneficial "negative" emotions:

> Patterns of affect associated with constructive engagement do not exclusively involve curiosity, excitement, fun, and satisfaction, but include feelings of impasse, frustration, and disappointment. When the emotional journey to mathematical success is arduous, even painfully so, the resulting satisfaction of achievement may be more profound. As mathematics educators, we must come to understand how ''negative'' feelings can and often do support engagement, persistence, and learning. (Goldin et al., 2011, p. 551)

Teachers of mathematics are therefore presented with the difficulty of creating "an emotionally safe environment" that also engages students through appropriate challenges, with students' current understanding and "psychological needs" in mind (Goldin et al., 2011, p. 554).

2.5 TEACHER KNOWLEDGE, BELIEFS AND DEVELOPMENT

Teachers work within specific contexts, responding to external requirements as well as student responses within their classrooms. It has been asserted that teachers are the primary "controllable" influence on student outcomes (Kleinhenz & Ingvarson, 2004, p. 32). As such, there is an abundance of research literature focusing on teachers of mathematics. The various foci of this research include: teacher knowledge; teacher beliefs; teacher preparedness following initial teacher training; the value of educational research for teachers; and professional learning opportunities.

2.5.1 Teacher knowledge

Teachers require various types of knowledge for teaching. Knowledge of the subject is commonly referred to as content knowledge. Knowledge of teaching methods and practices in general terms can be referred to as pedagogical knowledge. Knowledge specific to teaching methods and practices of a particular subject is referred to as pedagogical content knowledge (PCK), a term coined by Shulman in 1986.

Shulman investigated how teacher knowledge had been assessed over the previous century and found that there had been a shift from assessing content knowledge but no pedagogical knowledge in the 1870s, to a focus on pedagogy in the 1980s, with content knowledge "conspicuously absent" (Shulman, 1986, p. 6). Shulman also examined the literature on research in teaching and found that no questions were being raised about the content of lessons, with research questions focusing more so on classroom management, planning and assessment (Shulman, 1986). With a specific interest in teacher development, Shulman sought answers to questions about how teachers decide what to teach and how they make decisions during the teaching process, how types of knowledge are related, and the forms of knowledge required for an "expert student" to become a teacher (Shulman, 1986, p. 8). Shulman outlined categories of knowledge, including content knowledge, general pedagogical knowledge, curriculum knowledge, PCK, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of the values and purposes of education (Shulman, 1987, p. 8). In defining PCK Shulman (1986) refers to knowledge of representations, examples and other relevant choices a teacher makes in how to communicate content so that it can be understood by students.

These choices are influenced by the teacher's knowledge of students' ages and background, the teacher's knowledge of content in terms of its difficulty, and the nature of conceptual challenges the content presents. It is this amalgamation of content knowledge, pedagogical knowledge and knowledge of learners that presents itself as a teacher's PCK.

Shulman's work has an ongoing influence on research and has been cited prolifically in research into teacher knowledge over the last 30 years (D. L. Ball, Thames, & Phelps, 2008). Within mathematics education research it provided the foundation for Ball et al. (2008) to develop a theoretical framework of mathematical knowledge for teaching. Ball and colleagues recognised PCK as important but requiring further clarity in its meaning. They undertook studies of teaching in order to clarify the meaning of content knowledge and PCK in the context of mathematics education. Their work is based on the assumption that knowledge can be categorised and measured, with hopes that creating clarity in these terms will benefit research into identifying relationships between teacher knowledge and student outcomes, thereby informing teacher education, development and support. Ball et al. (2008) suggest that subject matter knowledge is made up of common content knowledge, horizon content knowledge and specialised content knowledge, while PCK is made up of knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum. In examining the type of knowledge pre-service teachers need to develop, Hine (2015) has identified mathematics knowledge for teaching as connected to both "quality instruction" and "students' achievement" (p. 4).

Shulman's work also influenced Rowland, Turner and Thwaites (2014) in their development of the knowledge quartet theory. This theory suggests that "foundation" knowledge underpins knowledge for "transformation", "connection" and "contingency" (Rowland et al., 2014, p. 320). Foundation knowledge is described as knowledge gained through personal and professional experience, education and training (Rowland et al., 2014). Transformation is knowledge that is visible through the choices made by a teacher in planning and delivery, for instance in the examples, representations and materials chosen to present concepts to students (Rowland et al., 2014). Connection refers to the level of achievement by the teacher of logical sequencing in their planning and teaching, as influenced by the teacher's knowledge of connections within mathematics and of the cognitive requirements of mathematical tasks (Rowland et al., 2014). Finally, contingency refers to the decisions made by the teacher as each lesson unfolds in light of student responses, which cannot always be predicted (Rowland et al., 2014).

In discovering what matters for student learning, some researchers claim that it is PCK rather than mathematics content knowledge (MCK) that has been found to influence student learning (Beswick & Goos, 2012). However, both Ball et al. (2008) and Beswick and Goos (2012) assert that, within research into knowledge, PCK has proven most difficult to conceptualise and measure, with more research required. The perspective that knowledge is context-related has challenged assumptions that knowledge can be categorised and measured. To elaborate,

> Teachers do not always employ the same sort of knowledge in apparently equivalent situations, and they draw upon a range of types of knowledge in relation to many of their everyday tasks, moving among them seamlessly and flexibly. Analysing and categorising their knowledge, although useful in many respects, risks losing an appreciation of the complexity of the work of teaching mathematics and may never be possible with complete clarity. (Beswick, Callingham, & Watson, 2012, p. 154)

Knowledge research has typically been based on a representational perspective in line with an acquisition approach and constructivist beliefs, with a number of more recent studies taking a situated perspective in line with a participation approach and socio-cultural theory (Barwell, 2013; Skott, Van Zoest, & Gellert, 2013). Barwell (2013) suggests that whether taking a representational or situated perspective, mathematical knowledge for teaching continues to be challenging to study. While Barwell (2013) asserts that discursive psychology may advance understanding of knowledge as it occurs in the classroom, the gap in research appears to be in discovering how teachers perceive their personal mathematical knowledge and mathematical knowledge for teaching to change over time and how teachers perceive this to affect their experience of mathematics education.

2.5.2 Teacher beliefs

Underway since the 1980s, the search for a reason for the slow uptake of reform has been described as stimulus for the abundance of research into teacher beliefs (Beswick, 2005; Skott, 2013; Skott et al., 2013; Thames & Van Zoest, 2013). It was asserted that teachers are unlikely to change their practice if new recommendations do not conform to their beliefs (Beswick, 2005), that beliefs can be difficult to change, and that beliefs which do not align with reform recommendations may even become the cause of a teacher's resistance to reform (Thames & Van Zoest, 2013).

A teacher's self-efficacy beliefs relate to the teacher's perceptions of his/her own ability to effectively influence learning. Research has shown that high efficacy in mathematics does not necessarily mean high self-efficacy in teaching mathematics (Stevens, Aguirre-Munoz, Harris, Higgins, & Liu, 2013). Similarly, Askew, Brown, Rhodes, William and Johnson (1997) found that the teachers with more subject knowledge were not necessarily the most effective. Higher self-efficacy has been linked to greater persistence, accountability, and the ability to build warm relationships with students (Nurlu, 2015). Some studies have found a correlation between teachers' self-efficacy beliefs and student achievement, with student achievement more strongly related to teacher-efficacy beliefs, which are beliefs about the ability of effective teaching to influence learning (Riggs & Enochs, 1990, p. 6). To clarify the difference, teachers may have high self-efficacy beliefs and therefore be confident in their own teaching abilities, but at the same time may not believe that effective teaching can help all students, reflecting low teacher-efficacy beliefs. The results of studies therefore infer that the students of teachers who do not believe they can be influenced are less likely to achieve in those teachers' classes than in a class where the teacher has both high self-efficacy and high teacher-efficacy beliefs.

When investigating teacher beliefs, researchers often use specific terms. It is important to clarify what is meant by the terms used. For example, 'attitude' could simply mean a positive or negative feeling towards an idea, person or thing, or it could be seen as having components of beliefs / knowledge, feelings, and "predisposition to act" (De Boer, Pijl, & Minnaert, 2011, p. 333). Likewise, double-barrelled questions in belief surveys can cause problems in data analysis – do low scores represent beliefs about their personal teaching abilities, or beliefs that some students cannot learn, or both?

Further limitations are acknowledged in terms of self-report surveys, as they rely on truth telling. Anonymity or building an atmosphere of trust is therefore important to reduce the likelihood of teachers giving socially desirable answers or report practices that do not reflect their everyday behaviours, to avoid revealing incompetence (Beswick, 2014). It cannot be assumed that teachers will not feel unhappy in some way, or possibly threatened, by a researcher's request for information, as demonstrated by feedback provided by participants in an Australian study 'Profiling Teacher Change Resulting from a Professional Learning Program in Middle School Numeracy', in which 36% of the participating teachers complained about having to complete the teacher profile (Watson, Beswick, Caney, & Skalicky, 2006).

Furthermore, what teachers report to believe in surveys does not always match what is observed in their practice (Schoenfeld, 2013). Various reasons for this have been considered, including sociocultural influences, which can lead to beliefs differing with context (Beswick, 2005). Alternately, there may be a lack of clarity or shared meaning between teachers and researchers of terms used in the survey, or teachers understanding of theories, such as constructivism, may not be complete, causing inconsistency between what they say and what they do (Beswick, 2005). There is also the possibility that teachers may hold beliefs which conform to the ideals of reform while being unsure as to how they can apply them in their practice (Beswick, Watson, & Brown, 2006).

A significant part of school reform over the last 50 years in Australia has seen students with disabilities increasingly integrated into mainstream classrooms and, today, very few schools of special educational needs exist. The context in which primary school teachers in Australia teach is therefore one of inclusion. Within the specific context of research into inclusive classrooms it has been found that higher teacher efficacy beliefs, higher self-efficacy beliefs and willingness by the teacher to accept responsibility for the new members of their class, are associated with greater acceptance of inclusion by teachers (Vaz et al., 2015). While teacher's attitudes have been shown to significantly impact the success of inclusive classrooms, it is also the case that self-efficacy and knowledge of appropriate solutions, rather than a negative attitude, can inhibit a teacher's ability to cater for the diverse range of needs in their classroom (Vaz et al., 2015).

It seems apparent that both beliefs and knowledge need to be considered together. Skott et al. (2013) investigated trends in mathematics education and acknowledged the advances made in research, in the fields of knowledge, beliefs and identity separately, but highlight the problem of studying them on their own by suggesting that this leads to "an incoherent view of the teacher and her or his role in instruction" (p. 501). The gap in mathematics education research therefore appears to be in exploring how teachers describe the relationship between their knowledge, beliefs and identity, how and why they perceive these to have changed over time, and how they perceive this to have affected their experience of mathematics education.

2.5.3 Teacher preparedness following initial teacher training

To teach in Western Australia, it is necessary to hold either a four-year Bachelor of Education degree, or a minimum of a three-year degree in addition to a two-year Master of Teaching, and these qualifications include the requirement for students to pass a personal numeracy assessment (Teacher Registration Board of Western Australia, 2020). The specific course structure in terms of units available to study and blocks of professional experience varies among the courses and universities in Western Australia, nevertheless each institution must provide opportunities for their students to demonstrate competencies as dictated by the Australian Professional Standards for Teachers, and include at least one quarter of a full-time equivalent year of study specifically on mathematics / numeracy (Australian Institute for Teaching and School Leadership, 2016).

The Teacher Education and Development Study in Mathematics (TEDS-M) provides an example of research into teacher preparedness internationally (Tatto et al., 2008). The TEDS-M investigates how each country provides avenues to become qualified as primary and lower school secondary mathematics teachers, including policy, curricula and costs, in addition to using questionnaires to establish the background characteristics and knowledge of future teachers. Information gathered from future teachers in the TEDS-M questionnaires includes: characteristics such as age and gender, previous career, highest level of education prior to teacher training and highest level of mathematics education; knowledge of mathematics content, mathematics PCK and general pedagogical knowledge; beliefs about learning mathematics, mathematics achievement and preparedness for teaching mathematics;

and opportunities to learn mathematics content, mathematics pedagogy, general pedagogy and how to teach for diversity (Tatto et al., 2008). Adapting the TEDS-M conceptual framework, one research study into Australian pre-service teachers' readiness for teaching mathematics found only 13.4% of participants to be completely confident to teach mathematics at the relevant year levels for their qualification, with 56.2% fairly confident and 30.4% either a little confident, not sure, or not confident at all (Beswick & Goos, 2012). The study involved 294 participants from seven different universities, together representing each state / territory in Australia.

Low levels of teacher preparedness for teaching mathematics could be related to assertions that, even in light of an abundance of research, there is a lack of agreement on how best to train teachers of mathematics (Hine, 2015). Hine's (2015) research with pre-service teachers found that MCK typically needed to be consolidated, and pointed to the importance of MCK for PCK to be effective. With respect to MCK, research suggests that more attention should be given to topics involving abstract thinking, but also that "simple knowledge and skills, such as the correct use of a ruler, cannot be taken for granted" (Beswick & Goos, 2012, p. 82). A positive correlation was found between the extent to which pre-service teachers had studied mathematics prior to starting the teacher-training course and their MCK as measured during the study, and the greater their MCK the greater their confidence. In contrast, correlations were not found between characteristics of teachers and their beliefs or PCK, despite participants coming from a range of backgrounds, courses and institutions. In explaining this, the authors (Beswick & Goos, 2012) suggest that:

> The pre-service teachers had not reflected on the nature of mathematics in order to construct beliefs about it that could provide a coherent basis for their views about teaching and learning the subject. Although happy to adopt the rhetoric of student-centred teaching, they may not, as suggested by Beswick and Callingham (2011b), have gone beyond the emotional attractiveness of such statements to consider their implications. (p. 85)

In addition, it was asserted that the lack of relationship between PCK and confidence suggests that the pre-service teachers are less aware of the importance and extent of their PCK, and they possibly have less experience of PCK assessments (Beswick & Goos, 2012). Given that PCK has been shown to "predict student outcomes" (Beswick & Goos, 2012, p. 86) these results indicate a necessity to address how mathematical PCK is developed throughout a teacher's career, in addition to addressing how it can be better developed during initial training.

2.5.4 The value of educational research for teachers

Teachers tend to value research if it addresses an issue of relevance to them, provides inspiration for their practice, can guide them in implementing specific teaching practices, or develop their knowledge on a specific topic, especially if it is supplemented with resources (L. Yates, 2004). Educational research is carried out so that teaching practices can be improved and so that suggestions for improvement are well supported (Dixon & Ward, 2015). There are several ways of communicating educational research, such as publication of a thesis, an article in an academic journal, or a book. Practising teachers may choose not to access as many published research articles or books that they are interested in reading, due to the costs involved (MacLellan, 2016). Even with access, the research may not influence teachers' practice because of technical language or a lack of guidelines making it difficult for them to understand how to apply recommendations (MacLellan, 2016).

As researchers and teachers operate in different 'communities', they may not share the same goals, identify with the same issues, or even understand the same terms / vocabulary in the same way, and so the extent to which theories, methods and tools developed by researchers are meaningful to teachers has been questioned (Potari, 2013). This issue is only confounded by the "huge variation and no common agreement as to what constitutes *quality instruction* in mathematics" (Mason, 2016, p. 222), as has been evidenced by educators watching the same video of a lesson and responding with a great variety of interpretations of that same lesson (Mason, 2016). Communities of practice exist spontaneously when peers feel a sense of belonging to a particular group and members engage collaboratively while coming to an understanding of their individual roles and aligning "themselves with established norms and values" (Goodchild, Fuglestad, & Jaworski, 2013, p. 395). Communities of practice have also been deliberately established within research circles in education with the aim of addressing the issues of teacher-researcher divide sensitively, by recognising how the analytical expertise of researchers and the practical experiences and expertise of teachers can complement each other in a mutual pursuit of knowledge, with shared purpose (Goos, 2014). Similarly, communities of inquiry aim to bridge the gap between research and practice by encouraging teachers to use research as a "tool for their inquiry" (Potari, 2013, p. 509). This approach is more critical, involving agency, goals, actions, "contradictions and tensions" (Goodchild, 2014, p. 178).

It is important for teachers to be able to analyse new research and to interpret and apply it, as appropriate, to meet the needs of their students (Connell, 2009). The value of supporting teachers in this endeavour is particularly apparent when the earlier discussion of education reform is considered: here it was inferred that when teachers are not given the opportunity to understand the research thoroughly and meaningfully, gaps between research and practice persist.

2.5.5 Professional learning opportunities for teachers

The Australian Institute of Teaching and School Leadership (AITSL) provides a framework of 'professional standards for teachers' which provides detailed descriptions of the expectations of "Graduate, Proficient, Highly Accomplished and Lead" teachers (Australian Institute for Teaching and School Leadership, 2018, p. 3). The Western Australian Department of Education has also introduced a Graduate Teacher Induction Program, which provides "targeted professional learning modules" (Department of Education, 2019). Professional learning (PL) opportunities are designed to provide an avenue for teachers to reflect on their practice - developing knowledge, skills and beliefs to enhance their practice. Ideally, they will provide opportunities for teachers to increase their understanding of the research on which current recommendations are based (Muir et al., 2010).

In the context of this study PL includes, but is not limited to, any professional / staff development that takes place at school or off-site, personal reflection, academic reading, attendance at conferences, participation in workshops, online or on campus training or study, work with researchers in education, and active involvement in communities of practice or inquiry.

Researchers have increasingly engaged teachers in a process of inquiry and reflective practice through projects involving Action Research, Lesson Study, and Communities of Inquiry (Potari, 2013). In contrast to the initial training of teachers, research into the PL of practising teachers is a relatively new and “ill-defined” field (Even, 2014, p. 330). University-based teacher educators, researchers, lead teachers and other PL providers do not have a common name, so for the purpose of this study, those who work with practising teachers to develop their teaching will be referred to as didacticians.

Until recently there has been little research relating to the training of didacticians, and future research into this field has been called for (Even, 2014; Sakonidis & Potari, 2014). Didacticians work with practising teachers, often with the aim of enabling teachers to relate and apply research and theory to their own practice (Jaworski & Huang, 2014).

Research that has taken PL as its focus has looked mainly at “process and outcomes” rather than how PL providers have identified the needs of teachers to inform the planning of their programs (Beswick, 2014, p. 83). However, concerns of top-down or politically driven programs that seek to change what teachers do have been raised, as studies indicate that they can be ineffective and meet resistance (Beswick, 2014; Muir et al., 2010).

It has also been suggested that teachers become increasingly resistant to change after reaching a plateau of growth and performance (R. Evans, 1996). Change can be difficult and has the potential to threaten the professional identity of teachers: with performance measures, and a fast pace reform that targets knowledge and beliefs, it is not what teachers do that is being challenged, but “what they are” (S. J. Ball, 2003; Beswick, 2014; Gellert, Espinoza, & Barbé, 2013, p. 543).

While research into how children think and learn is established, equivalent understandings of adult learning are in their infancy, and challenges are faced in applying constructivist approaches to teacher learning as “the conceptual domain is more complex and more uncharted” (Simon, 2013, p. 581). What is apparent, are the limitations of one-off PL sessions, which often fail to evoke “sustained changes” (Muir et al., 2010, p. 130). Features of effective PL include:

> It should be based upon consideration of students’ performances, be continuous and supported, be focused on collaborative problem solving, include opportunities for teachers to develop underpinning theoretical understandings, use multiple sources of information, and provide time for teachers to implement new practices. (Muir et al., 2010, p. 131)

Unfortunately, rather than engaging in a continual investigation of their teaching through critical reflection and collaboration, as in Lesson Study, teachers more often engage in short-term PL programs or research projects (Lerman, 2013). Lesson Study involves many teachers coming together to watch the same lesson, with lesson plans created collaboratively, the study of materials, an emphasis on teacher noticing during observation, and shared reflections from their personal observations (J. M. Lewis, 2016). Teacher noticing can be described as the attention a teacher pays to what the children are thinking, or strategies used by children, interpretation of students' understandings and the decisions made on how to appropriately respond (Scheiner, 2016). Lesson Study is part of Japanese teaching culture, where it is not funded or compulsory, but enables teachers to develop knowledge and improve their practice continually throughout their career (Groves, Doig, Vale, & Widjaja, 2016).

In contrast, it has been suggested that teachers in Australia work in a relatively fragmented system, where discussions of teaching and data will often take place removed from any shared experiences in the classroom (J. M. Lewis, 2016, p. 539). While Lesson Study provides a framework through which teachers' needs may be met, effective implementation of Lesson Study beyond Japan has been "uneven", possibly due to an absence of important school "structures and practices" (Takahashi & McDougal, 2016, p. 513). Lesson Study is a relatively new field of inquiry and research will continue, with some promising results from US studies which have shown improved teacher self-efficacy as well as participants changing their beliefs about teaching through their involvement in Lesson Study projects (Huang & Shimizu, 2016).

2.6 MEASURING AND REPORTING STUDENT ACHIEVEMENT IN MATHEMATICS

Within education, student learning and achievement is typically gauged through both formative and summative assessments. Within the classroom, formative assessment such as 'assessment for learning' can actively involve the student and provide opportunities for students to assess their own performance and progress (Hattie, 2012, p. 127).

Assessment for learning requires teachers to provide effective feedback and to evaluate student responses for the purpose of making relevant and appropriate adjustments to both activities in-the-moment and to subsequent teaching plans (Hattie, 2012). Assessment for learning strategies include teachers: clearly communicating learning intentions and success criteria to their students; facilitating classroom discussion, revealing current levels of student understanding; and encouraging peer learning (Hattie, 2012). In contrast to test-taking, this form of assessment informs in-the-moment decisions and draws on a greater variety of methods through which students are able to demonstrate their knowledge and understanding (Hattie, 2012). Research has shown positive correlations between this type of formative assessment and student attainment, with assessment for learning achieving “greater gains” than summative assessments (Hattie, 2012, p. 135).

One key element of assessment for learning involves teachers giving students feedback. For feedback to be understood and accepted by students: appropriate learning intentions and success criteria need to have been chosen by teachers and clearly communicated to students; teachers need to know their students, in particular their pre-requisite knowledge; and both teachers and students need to be invested and able to engage in the process (Hattie, 2012, p. 134). Even when these elements are in place, the process of giving effective feedback and having this feedback received as intended can be problematic: feedback is not always given when it is required; partial or unclear feedback leaves the messages given open to interpretations; students may hear what they want to hear and ignore elements of feedback that do not align with their existing beliefs; the feedback may be remembered incorrectly; positive feedback may be easily accepted, but negative feedback may be scrutinised and/or perceived to be resulting from external factors rather than associated with their own efforts; and praise is often included in feedback (Hattie, 2012, p. 136). Praise can be confusing to students, especially if they are not succeeding or understanding what is being taught, and it has been found that unnecessary or premature praise can actually deter students from reviewing and correcting their work (Hattie, 2012, p. 121).

Success in learning does not always mean getting the correct answer:

> Errors invite opportunities. They should not be seen as embarrassments, signs of failure, or something to be avoided. They are exciting, because they indicate a tension between what we now know and what we could know;

> they are signs of opportunities to learn and they are to be embraced. (Hattie, 2012, p. 124)

Research has found that creating a safe environment for students to investigate and learn from mistakes is beneficial to student attainment (Hattie, 2012, p. 125). Learning for mastery, as opposed to for performance, also helps students retain the content (Midgley, Kaplan, & Middleton, 2001, p. 78). To elaborate, students may aim to improve their mathematical abilities and master the learning content, or they may be aiming to avoid appearing as if they lack ability in mathematics - a performance goal. If an individual is focused on how their mathematical abilities are judged, and particularly where this places them in comparison to other students in the class, this can impact their behaviour, cognitive function and affective domain (Midgley et al., 2001).

Some research has shown positive outcomes of performance goals while other studies have revealed negative outcomes, despite investigating the same outcomes, such as: how students view themselves as learners of mathematics; affective variables; the extent to which academic work is valued; and student effort (Midgley et al., 2001). It has been suggested that the lack of consistency in results may be because of varying contextual factors, along with student's individual differences (Midgley et al., 2001).

More conclusively, research has found a positive correlation between performance goals and students "purposefully withdrawing effort (procrastinating, fooling around with friends instead of studying)" and this research suggests that these attempts at avoiding work are chosen by students so that this behaviour will be observed by others as the reason for low performance, as opposed to their performance being perceived as a reflection of their actual ability (Midgley et al., 2001, p. 81). Students with a performance goal orientation may also be less likely to ask for help (Midgley et al., 2001). It should be noted that the negative effects of performance goals are not restricted to low achieving students, with research describing how a high achieving student can be reluctant to attempt difficult work, "fearing that he might not receive the coveted 'A'" (Midgley et al., 2001, p. 82).

The majority of reporting on student achievement in mathematics is based on summative assessments. To elaborate, school reports in Australia involve compulsory grading of students on a 5-point scale (School Curriculum and Standards

Authority, 2014a). Unfortunately, stand-alone grades and NAPLAN results do not show progress, only where students sit against expectations for their year level. Furthermore, summative assessments, such as marks and grades, are often dismissed by students after they have compared marks/grades with their peers, with little evidence to show that marks/grades and accompanying comments trigger further learning or practice, as the work is seen as completed (Hattie, 2012, p. 135).

Furthermore, grades could be considered as a kind of 'label'. Negative aspects of labelling can include stigma, blame or control, whereas positive aspects can include appropriate intervention and greater self-understanding, and so the debate over the need for labelling and the danger of labels becoming a self-fulfilling prophecy continues (Riddick, 2012, p. 27).

However, student achievement is monitored in all Australian primary schools through NAPLAN testing, which applies to primary school students in Years 3 and 5 (Australian Curriculum, Assessment and Reporting Authority, 2016). Parents receive their child's NAPLAN results in addition to the regular school reports, written by teachers.

High-stakes testing has been criticised for typically being 'one size fits all' with a limit on time given to take the test, therefore not providing students with the opportunity to show what they can do (Cranley, 2018, p. 28). Bagnato and Yeh Ho (2006) suggested that "young children" cannot fully demonstrate what they are capable of when put in the artificial context of "sitting quietly at tables, responding on demand" (p. 26). Other factors that have been found to influence the performance of young children include: when the literacy demands within the test are too high; when the questions are unclear; or when it is not obvious to students from the instructions where to place their answers (Cranley, 2018, p. 29). Getenet and Fanshawe (2018) called for "future studies focusing on the validity of the NAPLAN tests" (p. 328), following their literature review on the uses of NAPLAN results.

While teachers appear to be aware that NAPLAN results are not always reliable, when there is a mismatch between the feedback given by teachers on school reports and NAPLAN results - especially when NAPLAN results were worse than expected - research suggests that this can negatively impact parent-teacher relationships, with parents losing faith in the abilities of their child's teacher to both teach mathematics effectively and to judge their child's performance (Cranley, 2018, p. 105).

Alternative approaches to teacher assessment are available, but research indicates that these are not necessarily providing adequate solutions to the problems highlighted. For example, Assessing Pupils' Progress (APP) has been introduced in England, but the steps involved in this include making judgements of students against 'predetermined lines', prompting researchers to ask "what is the teacher left with that might inform teaching and learning?" (Thompson, 2010, p. 135). Thompson (2010) concludes that "APP is far less useful, manageable and accurate than the guidance suggests" (p. 135).

Success in mathematics is more than just knowledge (Anthony et al., 2019). Further research into how student achievement in mathematics could be reliably determined and communicated appears to be necessary. As teacher retention is an increasing problem - due to excessive workloads and the variable support given to beginning teachers (Buchanan et al., 2013) - it would be necessary to not only consider the benefits of new modes of measuring and reporting achievement, but also the impact of new systems on a teacher's experience, as well as the support teachers would require for successful implementation.

2.7 SUMMARY AND IMPLICATIONS

In considering the historical context it is evident that what is expected of primary school mathematics teachers has changed over the years. In particular, teachers today need to be more cognisant of child development and to develop specific PCK. Researchers Beswick and Goos (2012) acknowledged the impact a teacher's PCK has on student learning, but found that PCK is difficult to conceptualise and measure, with more research into what underpins it and "how its development … can be enhanced" (p. 86) required.

In considering current research into the teaching and learning of mathematics, the literature reveals a lack of consensus as to what constitutes high quality teaching in mathematics. Recommended approaches for differentiation, or how best to meet the diversity of individual student needs, vary. Furthermore, while some researchers recommend a constructivist approach, or collaborative or discovery learning, others argue that these approaches are ineffective for children with learning difficulties. Combined with the fact that there is not one single remedial approach or tool that will be effective in every circumstance, it becomes apparent that the focus of teacher training and PL may well be variable and, if compared, is likely to include contradictory advice. It is not clear if this situation has any connection with teacher preparedness.

In measuring the preparedness of Australian pre-service teachers, the results of Beswick and Goos (2012) study showed only 13.4% of their participants were completely confident to teach mathematics at the relevant year levels for their qualification. These findings indicate that PL is essential, particularly in the early years of a teacher's career. However, research into the PL of practising teachers has been described as a relatively new and 'ill-defined' field (Even, 2014, p. 330).

With an increasing focus on and demand for STEM subjects (Timms et al., 2018), national agendas highlight the importance of success for all students in every school, resulting in pressure on teachers to address achievement standards. Unfortunately, it has been asserted that the curriculum changes and high-stakes testing that take place in an effort to increase standards could actually be depriving teachers and students of the opportunity to perform to the best of their abilities. Research suggests that teachers feel conflicted, discontent with the changes they feel they have to make, and concerned over the impact high-stakes testing has on their teaching and the consequent experience of their students.

Teachers of mathematics are presented with the difficulty of creating "an emotionally safe environment" that also engages students through appropriate challenges, with students' current understanding and "psychological needs" in mind (Goldin et al., 2011, p. 554). This is partly due to evidence, within mathematics education research, that the beliefs and attitudes of both teachers and students impact learning. For example, it has been found that a student's self-efficacy or anxiety can determine success more so than the mathematical tasks themselves (Kolacinski, 2003).

In exploring the professional and research literature on mathematics education, limitations and gaps have been identified which point to the importance of zooming in and out. To exemplify, when investigating what is influential for success in inclusive classrooms, teachers' attitudes and beliefs need to be considered alongside their knowledge of appropriate solutions. Furthermore, it has been found that what teachers report to believe in surveys does not always match what is observed in their practice, and it has been asserted that research focusing solely on teacher knowledge "risks losing an appreciation of the complexity of the work of teaching mathematics" (Beswick et al., 2012, p. 154). It has therefore been suggested that beliefs, attitudes and knowledge need to be considered together to establish a coherent "view of the teacher and her or his role in instruction" (Skott et al., 2013, p. 501).

The literature highlights the importance of supporting teachers in developing knowledge, skills and beliefs that will enhance their mathematics teaching. To achieve this, it is necessary to gain insight into their lived experience. Within educational research, the gap in research appears to be in zooming out and looking at the overall experience of primary school mathematics teachers, from an insider's perspective.

2.8 CONCLUSION AND CONCEPTUAL FRAMEWORK

Deriving from the literature and through a sociocultural lens, Figure 1 aims to depict the context in which a primary school teacher's experiences and perceptions form, and the resulting influence on student achievement. The educational framework, student relationships and teacher knowledge and beliefs intersect as these factors influence each other, and it is the combination of these factors that will shape the experience of teachers. Overall, the conceptual framework maps the research journey in terms of what has been investigated in the literature, its relevance and influence on the proposed study, and the significance of primary school teachers' experiences and perceptions of mathematics education in terms of student achievement. The literature has informed the research in providing an insight into the context in which teachers in Western Australia work, and this research investigated the perceived needs and lived experiences of primary school mathematics teachers within this context.

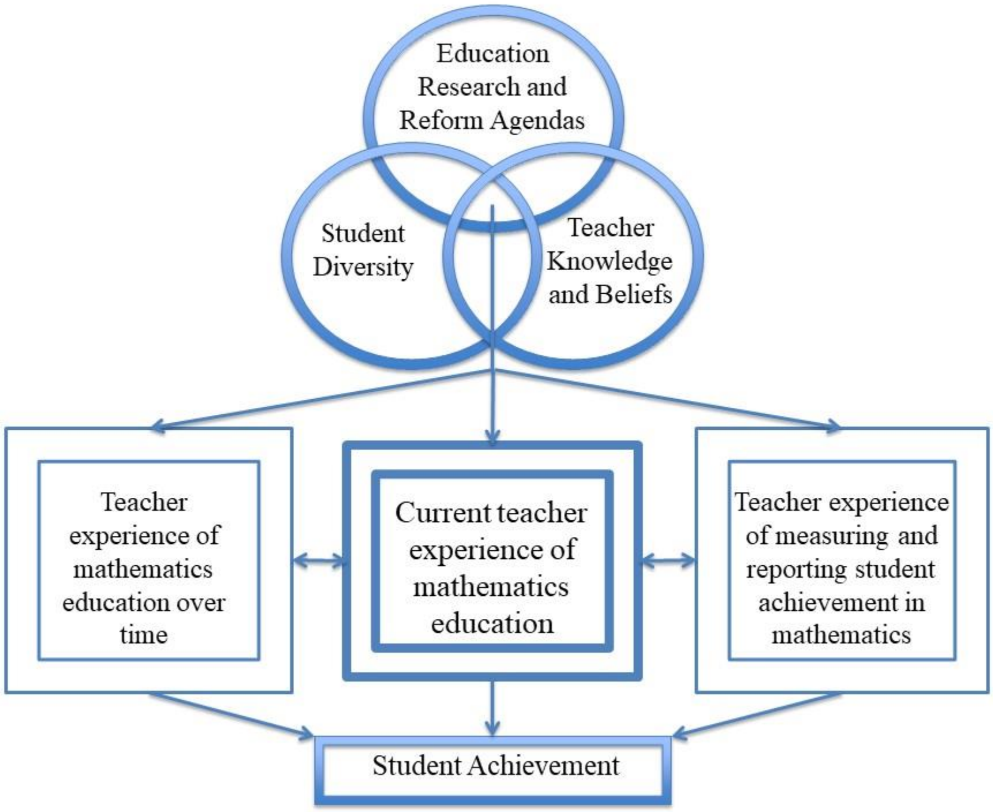

Figure 1 Conceptual Framework

Chapter 3: Research Design

Within educational research, the lived experience of primary school mathematics teachers in Western Australia has not been explored. This study aimed to avoid the limitations of looking at any one area, such as beliefs, knowledge or attitudes in isolation, while gaining an insight into teachers' experiences of mathematics education.

This study also explored if and how a teacher's experience of mathematics education changes during their career, and gains insight into teachers' perspectives of, access to, and use of professional learning opportunities. It is recognised that research requires a specific focus, that the background in many studies is therefore not disregarded but "out of focus" (Lerman, 2013, p. 629). Although limitations of existing research have been indicated in identifying the gap in research that this study aims to address, the value of the existing research is acknowledged, and the findings offer support for the premise of this study: the importance of supporting teachers in developing knowledge, skills and beliefs that will enhance their mathematics teaching. This support cannot be fully realised without insight into teachers' lived experiences.

To explore this phenomenon, the main research question asked: How do primary school teachers perceive and experience mathematics education? How primary school teachers perceive their experiences of mathematics education to have changed during their career is also considered. To answer the research questions the chosen methodology, transcendental phenomenology, focuses on the first-hand descriptions of participants and offers a scientific approach to describe lived experience.

This chapter details how knowledge was gained through this study. The theoretical perspective underpinning the chosen methodology is described, an explanation of how the research methods fit within this theoretical framework is given, and the suitability of these in answering the research questions is established.

3.1 THEORETICAL FRAMEWORK

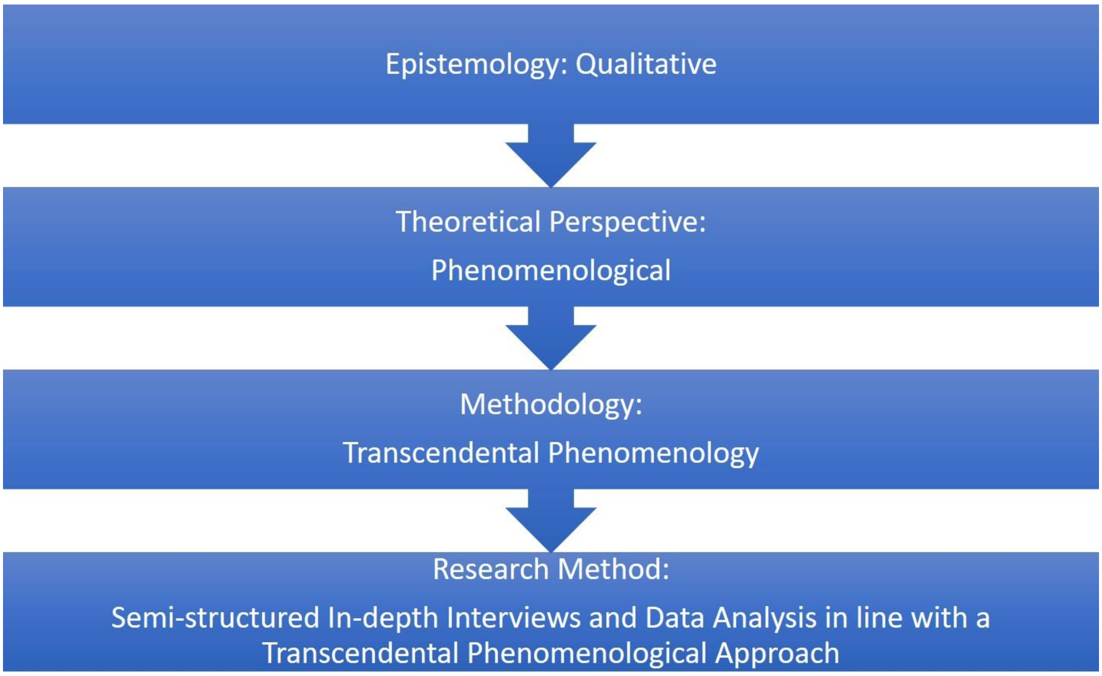

Figure 2 Theoretical Framework

3.1.1 Qualitative Research

Qualitative research is a relatively broad term, with the various types bound together by: the search for information involving personal contact between researcher and participants; studies taking place in natural settings rather than controlled environments; methods chosen to suit the context; and 'non-numerical' analysis of data (Tuli, 2011). The choice of methodology reflects ideas about the nature of reality and how we discover knowledge, and provides the rationale behind the methods chosen for the study (Scott & Morrison, 2007). In understanding the methodology, the suitability of the research methods for answering the research questions and addressing the research problem becomes apparent.

3.1.2 Epistemology, Ontology and Phenomenology

Ontological beliefs, about the nature of reality, drive epistemological beliefs, with epistemology encompassing "the relationship between the researcher and what can be known about that reality" (Harreveld, Danaher, Lawson, Knight, & Busch, 2016, p. 2). The choice of methodology for this study, phenomenology, reflects the researcher’s epistemological and ontological beliefs of social constructionism and relativism. Founder of transcendental phenomenology, Husserl, asserts “we come to an understanding with our fellow human beings and in common with them posit an Objective spatiotemporal actuality as *our factually existent surrounding world*” (Husserl & Welton, 1999, p. 62). Similarly, social constructionism acknowledges the part that culture has to play as individuals actively construct their understanding of the world (Crotty, 1998).

In the context of this study, Australian culture, the educational framework and each school’s individual culture plays a part in the social / shared construction of meaning of what it is to be a teacher of primary school mathematics, to belong to the school and to achieve in the profession. Relativism recognises that people construct their own meanings and thereby their own, individual realities (Crotty, 1998). In line with relativism, the subjective nature of knowledge is apparent in constructivist theory, as truth is negotiated within communities (Denzin & Lincoln, 2000).

It has been acknowledged that “phenomenology is a philosophy, a foundation for qualitative research, as well as a research method in its own right” (Eddles-Hirsch, 2015, p. 251). To elaborate, qualitative research endeavours to contribute to empirical knowledge by discovering a view of the world from the participant’s perspective (Corbin & Strauss, 2008), while phenomenology is essentially a philosophical investigation into conscious subjective lived experiences, or phenomena (Chambliss, 1996). Ontology, epistemology, logic and ethics are philosophical disciplines, and it has been suggested that phenomenology could join these, as a philosophical discipline in its own right, defined as “the study of our experience – how we experience” (Smith, 2018, Phenomenology and Ontology, Epistemology, Logic, Ethics section, para. 2). Husserl suggested the suitability of phenomenology as a rigorous science and although the ontological ideas behind realism and relativism seem contradictory, Husserl makes an argument for both. Realists believe in an objective truth, while relativists believe that truths are subjective and contextual. Husserl recognised the social construction of knowledge and that in changing his standpoint he gets new perceptions - the object remains the same, it is his perception of it that changes (Husserl & Welton, 1999). At the same time, Husserl does not rule out the possibility of understanding the true object completely, stating that continual multiple perceptions combine in consciousness, becoming increasingly more perfect, and that it is “erroneous to believe that perception (and … any other kind of intuition) does not reach the physical thing itself” (Husserl & Welton, 1999, p. 74).

3.1.3 Transcendental Phenomenology

There are different phenomenological approaches, including heuristic phenomenology, existential phenomenology and transcendental phenomenology (Eddles-Hirsch, 2015). The transcendental phenomenological approach, based on the work of Husserl, was chosen for this study. It suits the objective of describing the lived experience of mathematics education for primary school teachers and allowed the focus to rest on the first-hand descriptions of the participants, while offering a scientific approach in terms of the rigorous process of data collection and analysis, following logical steps to generate quality data.

Transcendental phenomenology requires the aspect of intentionality is expanded upon and investigated. Given human action as meaningful, it is therefore also intentional (Denzin & Lincoln, 2000). In transcendental phenomenology, *noema* and *noesis* are considered to make up all intentional experiences (Eddles-Hirsch, 2015, p. 252). The noema is the objective experience, the ‘what’ – in this case, primary school teachers’ thoughts, feelings and perceptions of mathematics education. The noesis is the subjective experience, the ‘how’ – in this case, the conditions, situations and contexts that give rise to the thoughts, feelings and perceptions experienced by primary school mathematics teachers. Through analysing data to establish the noema and noesis separately, connections between behaviour, thought and action may be discovered. Noema and noesis are then combined in a composite description, depicting the essence of the experience.

Implications of reflexivity are also expanded on in transcendental phenomenology, and as such it is advocated within this approach to engage in a process named *epoche* or *bracketing*. Bracketing is the dual process of acknowledging your personal interests and opinions and then letting go of those perceptions, letting go of the ‘ego’ or the need to be right and justified, so that space is created in which new possibilities for ‘seeing’ can emerge from a naïve standpoint and from a ‘transcendental ego’, meaning to transcend or go beyond the limits of your own ego or personal conceptions (Moustakas, 1994, p. 33). Husserl talks about Descartes doubting universally, and distinguishes the process of bracketing from this by saying we do not alter our conviction, but we put it “out of action” – a mental process (Husserl & Welton, 1999, p. 64). It is therefore the mental process, not of denial, but of shutting off judgement and becoming open-minded. In transcendental phenomenology, bracketing is essential throughout the research process.

3.2 RESEARCH METHOD

The research methods are the techniques used and procedures followed “to collect, analyse and interpret data” (Scott & Morrison, 2007, p. 152). For this study, the method of data collection was chosen in line with a transcendental phenomenological approach. This methodology also underpinned the procedures followed for data analysis.

3.2.1 Data Collection

Data for this study were collected through semi-structured in-depth interviews. During interviews, language is used to reveal meaning, which is negotiated rather than discovered (Denzin & Lincoln, 2000). Social constructionist beliefs come into play, as this negotiation process operates on the belief that knowledge is constructed in line with an individual’s existing beliefs and knowledge, and in light of the shared understandings and practices of others in their environment (Denzin & Lincoln, 2000).

It was essential for the researcher to be mindful of feelings and responses that could impact on the interactions and subsequent disclosures made during the interview process, to minimise researcher impact and bias (Corbin & Strauss, 2008). In line with guidelines for transcendental phenomenological studies, the process of bracketing was therefore used during the course of the interviews and data analysis process. Bracketing involved acknowledging personal experiences then letting go of assumptions, to be able to view the phenomena with fresh eyes, having transcended personal opinions.

The interviews lasted approximately one hour each, during which participants were asked about their experience of teaching mathematics. Further, as beliefs and knowledge develop through teaching experience, with early career experiences being a ‘key’ time for this (Beswick, 2012), the interview also provided an opportunity to clarify what had been significant in supporting the participants as they developed as teachers of mathematics. For re-registration purposes a minimum number of Professional Learning (PL) hours need to be recorded every five years, but there are no specific or minimum requirements with regard to the content, so how teachers make choices on what to focus on for their PL was investigated, obstacles in accessing PL identified, and the level of teacher engagement with mathematics PL programs and mathematics education research ascertained. In addition, views of published student assessments were sought. Finally, any concerns regarding student achievement were discussed, along with experiences in catering for a diversity of student needs.

Guided by these topics, the same interview guide was followed with each participant. However, the interviews were semi-structured, meaning that the interview guide was followed flexibly to facilitate the collection of rich data, with each topic introduced in a timely manner to fit in with the participant’s recount of experiences. If answers to the broad questions did not yield thorough, descriptive responses, then follow-up questions were asked, as necessary. Table 2, in Appendix A, displays the interview guide. Interview questions were adapted from Hall, Chai and Albrecht (2016, p. 138), and Moustakas (1994, p. 116). In addition to the research team, a critical friend viewed and provided feedback on the interview guide.

The interview questions were open-ended “in order to give the participants the opportunity to voice their own thoughts and opinions” (Eddles-Hirsch, 2015, p. 254). Additional prompts, such as ‘tell me more about that’, ‘can you give me an example?’ and ‘why do you think that is?’ (Hall et al., 2016, p. 138) were given as necessary for elaboration or clarification.

Interviews took place at the participant’s school, in line with the researcher’s aim to create a “relaxed and trusting atmosphere” (Moustakas, 1994, p. 114). All interviews were recorded and transcribed and participants were assured of confidentiality and anonymity, and reminded that they could withdraw at any time. Other researchers, to concur on identified themes, viewed the transcripts, but pseudonyms were used. In addition, participants were asked to review a summary of the data analysis and themes to confirm validity of the data.

3.2.2 Participants and Study Context

For this study, to gain insights into primary school teachers' experiences of mathematics education, it was necessary to interview teachers who had experience of teaching primary school mathematics. The 12 participants in this study had between two years and 30 years of experience and taught a range of year levels, from Pre-Primary to Year 6. As a phenomenological study requires an in-depth exploration of experience a large number of participants was not required, with five to 25 people forming an adequate sample (Creswell, 2007, p. 121). However, it is necessary to gather different perspectives of the phenomenon, in this case mathematics teaching and learning, so it was appropriate to interview teachers from a range of year levels within the primary setting. Interviews continued until new information did nothing to further understanding of the phenomenon, at which point "saturation of data was achieved" (Creswell, 2007, p.271).

Purposeful sampling was used to identify primary school teachers who had taught mathematics for at least two full-time years or equivalent, and it was also necessary to establish further boundaries. The school context influences teaching and learning and a great diversity of 'characteristics', or school contexts in this instance, is likely to make the identification of common themes and the essence of the experience for all participants difficult to find (Creswell, 2007, p. 122). The number of public primary schools within the Perth metropolitan area alone is extensive, and reliably identifying similar schools within this system could be problematic, so it was decided to invite participants from a smaller group of like schools for the purpose of this study. Invitations to participate were therefore given to teachers working within co-educational low-fee paying primary schools located in the Perth metropolitan area and registered with the Association of Independent Schools of Western Australia.

For participants to be included in the study, they had to be willing to describe their experiences of teaching mathematics in a recorded interview. Participation was voluntary, consent forms were completed prior to data collection and participant anonymity was guaranteed, with pseudonyms adopted. Recruitment of participants was achieved through sending letters of invitation to a number of schools. Two schools responded, each with six participants willing to take part.

3.2.3 Quality of Data

To produce quality data it was necessary to understand fully the principles of phenomenology and to follow the associated rigorous procedures of data analysis, including accurate transcription of the interviews (Creswell, 2007). It was important to remain reflexive throughout the research process by acknowledging and bracketing personal experiences and beliefs in order to accurately convey the experience of the participants (Creswell, 2007).

Data were gathered until saturation occurred, a more experienced researcher checked coding and alternative conclusions were identified and investigated (Creswell, 2007). In addition, a summary of the findings was sent to participants, providing an opportunity for feedback to be given and any misunderstandings to be addressed. Feedback received was positive and no participants wrote to say any changes needed to be made, or that omissions had been made. These strategies support the trustworthiness and dependability of the study, which forms the basis for validity. Furthermore, the presentation of findings and conclusions in the following chapters are evidenced by quotes from the raw data so that connections between the two are clear. Finally, the study aims to show reliability through credibility, by asking appropriate questions of relevant people in order to answer the research questions.

3.2.4 Ethical Considerations

This research project did not commence until the process of ethics approval, through Edith Cowan University, had been completed successfully. The research project was then conducted in accordance with the approved ethics application. Information letters and consent forms were sent to schools and completed by the school principal for each participating school, and by all participants. Participation in the project was voluntary. Research participants were required to give informed consent before data collection began and were advised that they could withdraw from the project at any time.

Data were treated confidentially and anonymity of participants guaranteed. The researcher has no authority over the participants that could influence participant contributions to the research and the project did not have any negative effects on the participants. All records and recordings have been kept on a password protected computer and/or in a locked filing cabinet.

3.2.5 Data Analysis

In transcribing the interviews, the researcher gained familiarity with the experiences of the participants. Data files were created and organised. The phenomenological process of bracketing was necessary again before reading the transcripts to make margin notes, to identify significant phrases, and to begin initial coding. Within a phenomenological study, to assist the researcher in gaining empirical knowledge, the processes of transcendental reduction and imaginative variation are engaged in during data analysis. The steps of data analysis, adapted from Moustakas (1994), Creswell (2007) and Eddles-Hirsch (2015) were:

1 Transcendental reduction began with horizontalization of the data, meaning that significant statements were extracted from the interview transcripts. These are statements that describe the noema and are necessary for understanding the experience. Moustakas (1994) recommended that the following questions are asked about each statement: "Does it contain a moment of the experience that is a necessary and sufficient constituent for understanding it? … (and) Is it possible to abstract and label it?" (Moustakas, 1994, p. 121). Each statement that meets these requirements is a "horizon of the experience" (Moustakas, 1994, p. 121). Statements not meeting those requirements were removed, as were vague or repetitive statements. Equal weight was then given to the remaining statements and "the horizons that remain are the invariant constituents of the experience" (Moustakas, 1994, p. 121).

2 Imaginative variation or eidetic reduction required seeing the phenomenon from different perspectives, considering the various possible conditions, situations and contexts that gave rise to the noema, to establish meaning from the invariant constituents. The statements were then grouped by their meaning into themes, thereby generating the noesis (Eddles-Hirsch, 2015).

3 Composite descriptions or essence. It is the composite descriptions, in which the noema and noesis are put together, that provide the final essence of the

experience (Creswell, 2007; Eddles-Hirsch, 2015; Moustakas, 1994). Firstly, individual narratives were written for each participant. Then, using common themes, a final narrative representing the lived experiences of the participants as a group was created. The aim of the final narrative is to enable the reader to feel they have a better understanding of what it is like to be a teacher of primary school mathematics in Western Australia.

To demonstrate, the application of the data analysis process is now applied to one of the interview transcripts - that of Stacey (pseudonym). The first step in data analysis was to extract horizon statements from the interview transcript. Horizon statements are those relevant to understanding the phenomena of mathematics education. Stacey's horizon statements are listed in full in Appendix B, along with the full interview transcript. A sample of Stacey's 100 horizon statements is given below. Stacey was teaching Year One and had been teaching for seven years, always in either Kindergarten, Pre-Primary or Year One:

6 … you get to really sit in the knowledge, it's not moving too fast, they really get to build their own understanding

17 … I find in maths it's, there's just so many things that underpin everything

27 … I wouldn't know what goes on in the next year level, or know the terminology that gets used

29 … I'm very like insular in Year One and I stick to the Year One knowledge, and that's probably a negative because, like, especially when I have high achievers or children who need remediation, I, I don't always have the scope of what's going on in the other year levels

30 … definitely different school to school. This school has a big focus on enquiry, um, and on questioning and understanding. In my last school it was explicit education was the big focus and that took away from hands-on at times, um, it was a Pre-Primary class and I had a lot of PowerPoint presentations to introduce topics rather than a hands-on experience, and that was a very different way of teaching, um, and that took away from my own pedagogy of 'maths should be hands-on in the early years and written after you understand it physically'

34 … particularly for Pre-Primary and Year One, um, so that they have the time to settle in and there's not pressure to work too fast or jump too fast

59 … I'd been at an EDI school…explicit direct instruction and they, it had become very worksheet based, very, you know 'I say, you copy' … then coming to a school that was about enquiry and about understanding first, I, it was a big shift towards more play based

74 … being a mathematician was a real career… (now) computers can do maths quite well… in comparison to people, so, our maths skills, in some ways are more important, because we need to be able to identify when things go wrong, um, and we need to be able to critically view mathematical data

75 … mathematicians just as a number cruncher has, we've definitely moved away from that as a career, and so I do, kind of, I read the research and I know that we're really lacking in those areas, but (don't know why)

76 … the (assessment) that I've used most commonly is the on-entry assessment from the West Australia education department, um, and that's a really nice assessment… it's very much about what they already know… you get back the feedback for which skills children are lacking

79 …I've been able to target weaknesses. So, when I've got one or two children in a cohort who missed a question, um, like maybe counting by collections, I'm actually able to take those children and pull them aside and just do a big focus for two weeks, a week, until they've mastered that skill, and then it brings us all back to an even playing field, um, and that's really meaningful

80 … that kind of diagnostic test…being able to build on from that to the skills that we need…that's where good assessments…really have an impact

93 … but it does kind of play on your mind… especially when it's a concept that you kind of need before you're doing another concept, things like counting collections, if you can't count a collection we can't really move into sharing or into addition or subtraction or grouping - all of that stuff kind of grinds to a halt because you can't subitise, you can't count… so that's quite a big thing

This sample of horizon statements was chosen to exemplify the process of reduction and elimination, and the identification of a theme. Through a transcendental phenomenological approach, horizon statements are subject to a process of reduction and elimination, so that the horizon statements that remain are called the invariant constituents. It was difficult to eliminate statements as they all seemed relevant. Table 1 summarises the statement numbers that were deleted and the reason for this:

Table 1
Reduction and Elimination, Stacey

Horizon Statement Number	Reason for Elimination
27	Repeated in 29
76 and 79	Repeated in 80
59	Repeated in 30
34	Repeated in 6
75	Implied in 74

In the second step of data analysis, through a process of imaginative variation, the conditions, situations and contexts that gave rise to the participants' thoughts, feelings and perceptions of mathematics education were considered. In this way, the invariant constituents could be grouped by their meaning into themes, thereby identifying the noesis.

An example of this second step, with reference to statements made by Stacey, is now given:

Mathematics concepts and skills are interconnected and build hierarchically (#17,29,80,93)

Mathematics education requires communication and the language of mathematics includes the use of specific symbols, some exclusive vocabulary which will be new to learners of mathematics, some words with specific meanings in mathematics but a different meaning in everyday contexts, and groups of words that can have the same meaning (such as add, plus, sum). To understand mathematics often requires links to be made between words, symbols and concepts. Explanations of mathematical ideas can vary (#3,4,8,9,32,97)

Within mathematics education, hands-on activities and materials are used to support a student's developing understanding of concepts, and to assist students in identifying patterns and connections (#5,24,98,99,100)

Mathematics education can be isolated or integrated across the curriculum (#81,82,83,84,85,86)

The skills and understandings developed through mathematics education are generally viewed by educators, students, schools and parents as useful and important for later learning and life (#63,64,65,66,68,70,71,72,74,96)

Success in mathematics education can be viewed in different ways, such as understanding content, being able to carry out procedures, applying this knowledge to solve problems, reasoning effectively to explain answers or extend knowledge, obtaining skills for life, or having a positive disposition towards mathematics (#60,61,62,66)

The National Assessment Program (NAP) uses national numeracy tests and international assessments to measure and monitor progress towards achievement outcomes and publishes results for government, the education community and the broader community (#45,73,77,78)

Mathematics educators are required to teach, assess and report in accordance with the mathematics curriculum (#6,7,32,33,35,36,39)

Different schools encourage different pedagogical approaches to mathematics education (#20,22,23,30,31,40,41,42,55,57)

Resources to support mathematics education vary in quality, availability and suitability (#37,38,50,51,52)

Students interpretation and understanding of mathematics, and therefore their responses to mathematics education, varies (#10,11,69,78,89,90,91,92,95)

A student's beliefs, attitudes, anxiety and expectations can generate failure in mathematics education and this can be pervasive, impacting other areas of learning and their life (#67)

Teachers play an important role in student learning and a teacher's beliefs, attitude, expectations, Pedagogical Content Knowledge (PCK) and lesson preparation impacts the quality of mathematics education students receive (#12,13,15,18,19,29,87,88)

Mathematics educators are influenced by, and draw upon, past experience (#1,2,14,16,25)

Mathematics educators undergo initial training and are then encouraged to engage in reflective practice and professional development (#21,26,28,43,44,46,47,48,49,53,54,56,58)

The third step of data analysis was to create a composite description of the experience, starting with individual descriptions for each participant. To exemplify, here is an extract from Stacey's individual description:

Stacey recognises that, with the STEM movement, "maths has become a huge focus again". She speaks about the importance of student understanding of primary school maths, in preparation for later learning, as well as considering the maths skills needed in careers today, "we need to be able to identify when things go wrong, um, and we need to be able to critically view mathematical data". Stacey describes maths as "at times, very black-and-white about the actual maths skill" and believes it's an area where teachers, at times, can "feel that it's a bit like, ooh, I don't want to do it wrong… I don't know the best way of doing it um, and, you know, will I cause more confusion and will I make it harder for the children?" She remembers her teacher training, saying "we did three units on maths and we got taught lots of strategies on how to teach maths, and we did go through a maths textbook… I don't know whether I got a quality education out of doing a textbook". She reflects on her experiences since, "in the seven years I've been teaching I feel like I'm a lot better at teaching maths. Um, just because I a) have the time to go confirm things, or I'm like oh yes, I told my class this last year". She doesn't feel that she's done "anything that's been hugely revolutionary in maths for PD wise" and hasn't "done very many formal courses". In choosing what to engage in in terms of professional learning, Stacey says "it's not very driven by anything…it has to connect to the teaching standards, but it can be a bit quick, it can be a quick one-day course to cover the maths area". She identifies her learning needs by reflecting on her "own feelings, um, and about how I feel I went with things and what I'm struggling with".

Full individual textural descriptions for each participant are in Appendix C. Finally, to form a composite textural description, common themes were identified and used to produce a final narrative representing the lived experiences of the participants as a group. The final narrative is presented in full in the following chapter. To further exemplify the process of data analysis, the interview transcript, invariant constituents and themes from another participant, Gemma, are given in Appendix D.

3.3 SUMMARY

Through a phenomenological approach the subject and object can be distinguished yet united, the interaction between them creating the images or essence of what it is like to be engaged in the experience (Crotty, 1998), mathematics education in this case. The focus is therefore not solely on the participants and how they construct their experience, nor on their working environment that shapes their reality, but on the relationship between the two. This qualitative approach allows the focus to rest on the wholeness of the experience and search for meaning and essence in a problem that reflects the interests of the researcher (Moustakas, 1994). It meets the aim of this study, which was not to measure, establish a cause and effect relationship or generate a theory regarding mathematics education, but to analyse and describe the experience of teaching mathematics in primary schools.

This chapter has described the methodology and research methods, including a detailed outline of the process of data analysis. The following chapter provides the findings in the form of a final narrative.

Chapter 4: Findings

The purpose of this chapter is to present the findings from the research on how primary school teachers perceive and experience mathematics education, and how primary school teachers perceive their experiences of mathematics education to have changed during their career. Data for this study were collected through semi-structured in-depth interviews and have been analysed in line with a transcendental phenomenological approach.

The major themes that emerged from these data were: learning mathematics; learning how to teach mathematics; success and accountability; the impact of the working environment; and perspectives of students in mathematics. These themes have been used to structure the final narrative.

4.1 PRIMARY SCHOOL TEACHERS' PERCEPTIONS AND EXPERIENCES OF LEARNING MATHEMATICS, AND LEARNING HOW TO TEACH MATHEMATICS

Primary school teachers have had to study mathematics at school as well as learn how to teach mathematics at university. The findings indicate that learning about both the subject of mathematics and mathematics teaching continues throughout a teacher's career.

4.1.1 Specific characteristics of mathematics and implications for teaching and learning

Mathematics was perceived by the participants in this study as having specific characteristics which directly impact learning, such as the subject being structured, abstract and requiring specific terminology.

In terms of structure, mathematics concepts and skills build hierarchically and are also interconnected. This structure affects learning as it means that each stage of learning is important to master for further learning to take place:

> When it's a concept that you kind of need before you're doing another concept, things like counting collections, if you can't count a collection we can't really move into sharing or into addition or subtraction or grouping - all of that stuff kind of grinds to a halt because you can't subitise, you can't count… so that's quite a big thing. (Stacey)

For teachers, depending on their knowledge and understanding of learning trajectories and connections, the hierarchical nature of mathematical skills and knowledge can assist them to plan an effective learning sequence. Equally, a lack of understanding can hinder their ability to support student learning:

> In maths it's, there's just so many things that underpin everything, and there are rules for everything and if you don't understand those rules then you miss an opportunity to explain it to the children who are working at a higher level, or even to the children who aren't understanding it themselves. (Stacey)

Some teachers looked to the mathematics curriculum to develop this knowledge, while others have found that working with different year groups has helped:

> I love just reading the scope and sequence to see where they go down and up. (Paul)
>
> I got to learn the Year Four, Five and Six curriculum really well … it made me a much better teacher. (James)

Stacey described the disadvantage of a lack of knowledge regarding the scope and sequence of the mathematics curriculum, finding that this prevents her from being able to meet the needs of students who require support or extension. Stacey had taught the same year level for several years and had not explored the mathematics curriculum beyond that year level:

> I'm very like insular in Year One and I stick to the Year One knowledge, and that's probably a negative because, like, especially when I have high achievers or children who need remediation, I, I don't always have the scope of what's going on in the other year levels. (Stacey)

However, many of the participants used their knowledge of learning trajectories to identify and address gaps in student learning:

> I teach in upper primary, Year Sixes, um, a lot of times we've got to back track and we go back through the lower levels and say, okay, what building block did they miss, that means that they don't get the concept that we're working on at the moment? So, we go back and re-teach, and explain that to them, and lot of times then you have that lightbulb moment, and they get something, you can see it. (Michael)

> I'm a huge believer in you go backwards, find out where they're comfortable, and then move them forwards again. (Zoe)

In order to achieve this, many of the teachers spoke about using diagnostic assessments:

> That kind of diagnostic test…being able to build on from that to the skills that we need…that's where good assessments…really have an impact. (Stacey)

While learning trajectories can be mapped theoretically, the learning journey of students in mathematics is not always smooth. Shaky foundations, including misconceptions, can cause students to go off track or be held up. Teachers of mathematics need to navigate their way through the complex web of mathematical knowledge, understanding both the theoretical construction of this knowledge as well as discovering how the student has understood and put together their individual understanding of mathematics, to decipher where and how issues have occurred. To overcome the roadblocks, smooth out the path and enable a student to proceed, teachers also need to know how to address the identified issues, and how to progress the student's knowledge and understanding. When comparing mathematics to other subjects, teachers can find the extent and impact of the sequential nature of mathematics to be unique:

> Maths is very linear. You know, each step builds on the one before, unlike other areas which can be quite nebulous. (Michael)
>
> If there are some foundational things that are just not there in maths then, then, there is likely that nothing will be going right. Whereas, you know, their spelling can be atrocious but they could still, I can still, eventually, get out from what, from them what they actually mean or, if their handwriting's bad then they can write on an iPad, like there are, there are ways for them to still continue to push themselves through those sort of early content barriers, but with maths there just isn't. (James)
>
> A lot of the time what will happen is that often lower primary teachers don't feel like they can teach upper primary because 'oh, you guys do scary maths up there' um, or 'one of my kids in Year Two is doing Year Four or Five maths concepts and I don't know how to support him' or, um, it comes down to 'one of these Year Six kids, um, is still at Grade Two, um, maths, I don't know where to start with them'. (James)

> I think there would be huge anxiety if you dropped me up into Year Six class teaching maths, compared to another subject. (Stacey)

The abstract nature of mathematics can also make learning mathematics challenging. Within mathematics education, hands-on activities and materials can be used to support a student's developing understanding of concepts, and to assist students in identifying patterns and connections. To understand mathematics often requires links to be made between words, symbols and concepts. All the teachers in this study spoke specifically about scaffolding learning from concrete to abstract or using hands-on activities, and/or relating the mathematics being taught to real life contexts. These strategies were seen as crucial for student engagement and understanding:

> Really four plus two means nothing, but you have to put it in context. (Adam)
>
> I wasn't scaffolding properly, I wasn't connecting it with their real-life experiences… you need to do that for all the subjects, but it's even more relevant for mathematics… because… for history and for science, they can all be connected anyway, I think they can make that association, but sometimes I think with mathematics, there is that gap, between maths as a concept and then life, and they don't seem to be able to bridge that. (Paul)
>
> In Year Five we try very much to put maths into the context of life and the world, and especially for those kids who have been a bit, um, there's just no connection to maths, or they're feeling they just don't get it. (Zoe)

Some of the teachers in this study related the aspect of hands-on activities to mathematics being a fun and enjoyable lesson, with Amy stating "if you can bring in those hands-on activities it can be quite enjoyable". In conjunction with hands-on learning, when Laura described how she scaffolds learning she highlighted the importance of being explicit in mathematics teaching:

> Being really explicit, I think that's really important. Even though you have these hands-on and somewhat play based stuff, that's still really, really important I think that's where all the learning comes from, the foundation. Um, but then, you know, using those hands-on and tactile things if we're learning about place value, actually getting the MAB blocks out, getting the kids to hold, count them, you know, and go from place value and using them to do addition or double-digit addition, actually getting them to see what it

> looks like and then writing it down and then slowly, gradually taking those things away. (Laura)

In order to be explicit, mathematics education requires verbal communication and the sharing of understanding and ideas. Claire believed "it's almost like it's a foreign language to a lot of students". To elaborate, the language of mathematics includes the use of specific symbols, some exclusive vocabulary which will be new to learners of mathematics, some words with specific meanings in mathematics but a different meaning in everyday contexts, and groups of words that can have the same meaning (such as add, plus, sum). Explanations of mathematical ideas can vary and Stacey described how this can impact both her teaching and her student's feelings when learning mathematics:

> I had this panic that, oh, some people say this…the true mathematicians say this, and Google tells me this, and it was one of those things where I couldn't just answer it straightaway. (Stacey)
>
> We discuss it a lot, and we put together our own definitions, and then we confirm with things, and I feel like for some children, they're a bit frustrated by that because they've either been told a definition, or been explained something, and that's the only way of doing it. (Stacey)

Many of the participants described specific strategies to assist their students' learning of the specific terminology of mathematics, in particular class discussion time and creating opportunities for peer learning. Sam used reflection flags to initiate discussions at the end of her mathematics lessons and she found, "that's a great way to recap and reinforce key messages or mathematical language or concepts from the session" (Sam). Paul described feeling challenged by some of the stages students appear to have to go through in order to learn the language of mathematics:

> That for me has been a real issue that I've had to grapple with to allow them to sometimes use the incorrect words, sometimes use the wrong definitions, sometimes use the wrong language, but actually that's how they're actually going to understand those concepts because, that's how they're going to comprehend it. They're not going to use my language, um, because they don't know it yet. (Paul)

Amy recognised the barrier of mathematical language and described how peer learning can help to overcome this:

> A lot of kids will go through and not actually understand some of the words that are associated with addition and subtraction and, you know, a whole range of things… sometimes when another child is explaining to another child, they can actually do it better than we can do, because they can get on their level and they can use what they need, the language that they need, and, and that's really helpful as well. (Amy)

Michael also described the necessity of peer learning, stating "sometimes you've got to leave it to a student to explain it to another student because they talk the same language", and Gemma recognised that confusion over mathematical words can affect students when they are being assessed in their learning of mathematics, "for NAPLAN if they read something and they don't even understand what that vocab means, … that really has a big impact". (Gemma).

4.1.2 Learning how to teach mathematics

The findings indicate that in learning how to teach mathematics teachers: draw upon their own past experiences as learners of mathematics; undergo initial training but feel a level of unpreparedness when they first start teaching; value internal support; and may attend external Professional Development (PD) sessions to develop their Pedagogical Content Knowledge (PCK).

In response to their own experiences as students learning mathematics, the participants in this study described being influenced by, and drawing upon, their past experiences as learners. Many were motivated in their teaching of mathematics to compensate for earlier experiences. For instance, if they had been rote taught, or felt intimidated as a student of mathematics, or if they had struggled to stay engaged when learning mathematics, these teachers were motivated in their teaching of mathematics to teach with understanding, nurture their students, or explore various strategies to keep their students engaged respectively:

> I just did it - my expression as a teacher is 'as a trained monkey' - I had no idea really what was happening with the numbers … (I) try and find ways of connecting the maths concepts to real life because I think that's what my diet of maths education lacked. (Claire)
>
> When I was in Year Two if I got an answer wrong the teacher would be like 'boom' and you go 'ooh', so not to be like that. Just to be like, that's okay,

> let's have a look at it with fresh eyes, or, let's come back to it, or, let's highlight the keywords in the question, you know, what are the different ways we could solve this problem? (Sam)
>
> Growing up I always had that kind of negative feeling towards maths because I found it difficult to focus on what the actual concept was, that's why I try to incorporate things like videos and hands-on stuff, so, so that it's a little bit more interesting and maybe the kids can stay engaged. (Amy)

Similarly, some teachers were motivated in their teaching of mathematics to replicate their earlier experiences, if they had had positive role models:

> I still look at the way that I was taught mathematics in high school… my great inspirational sort of mathematics teachers that I used to have, who just loved it, who just geeked out about mathematics. I think sometimes I tend to, tend to do that…I frankly don't remember a lot of things that I did in high school, but I do remember feelings that I had when I, when I saw my teachers get really excited about it, so I'm hoping that's what they get. (Paul)

Regardless of positive or negative experiences as learners of mathematics, many of the teachers in this study appeared motivated in their teaching of mathematics to transfer positive feelings about mathematics to their students:

> I love it…I actually want to transfer that back, that enjoyment back to the students. (Rachael)
>
> I enjoy it. I've, I was always very good at maths, so I like the idea of imparting that, and I like helping students who, it seems to be, find maths quite scary. (Zoe)

While all the participants in this study displayed a positive disposition towards teaching mathematics, some indicated that their feelings about mathematics had changed during their career:

> It's something that I enjoy more (now), so I think if you enjoy it more the kids enjoy it more. Yeah, so I don't know why that changes, it's just your personal, um, I think it's just your personal growth. (Gemma)
>
> This is my ninth year of teaching, and I feel I've really only fallen in love with it probably in the last say two to three years. (Sam)

As a student, Stacey did not enjoy mathematics and admitted that a feeling of anxiety could persist in some areas of her mathematics teaching. Stacey recognised the important role she plays in student learning and how her PCK and lesson preparation impacts the quality of education students receive:

> From a personal level, a bit of anxiety … I didn't enjoy maths at school, and sometimes I'm like, oh gosh, do I understand it enough to explain it … it's not too bad if it's something that I'm familiar with teaching or it's something that I've planned for, if I know that the lesson is going to be about a topic I can do research and I can plan, I can have the answers ready, but it's when those incidental teaching moments come up … and I just haven't had the time to confirm the knowledge that I have and confirm the right language to use. So that, yeah, kind of frustrates me and it frustrates them … and that's where I guess some of the pressure comes from, because it's my voice that they're going to have on their head, or they're going to have my language, and you sometimes feel like you might not be using the best word, or the best way of explaining it. (Stacey)

In order to become primary school mathematics educators, teachers undergo initial training and are then encouraged to engage in reflective practice and professional development. All the teachers in this study felt that they had improved in their ability to teach mathematics during their careers, after experiencing a level of unpreparedness when they first started teaching:

> From a tertiary level … I felt I came out with the theoretical understanding, but that's one thing, but as teachers we need both, I feel, so there wasn't enough practical in our teaching. (Sam)
>
> When I first started … I just … got them to do questions and like there was no 'how can I make this fun' and 'how can I make it interesting' … I was just used to getting them busy doing questions and there was no thinking about it rather than trying to provide opportunities for kids to think and evaluate what went right, what went wrong … (there) probably wasn't that scope for differentiation whereas now I try to differentiate a lot more than when I first started. (Adam)
>
> Just learning what actually, um, what a maths lesson looks like as well, and how explicit you need to be, um, and examples and everything else, like it's quite a big, it's a big learning curve so you kind of don't realise just how, um, how much you have to scaffold them, at the start of the lesson, and then move them through, and all those diagnostic assessments, and all the other stuff that you learn as you go along, so it is a big difference from when you

> start to when you get to this point, you kind of know how you're going to structure your lessons… for those first probably couple of years it was probably my weakest area, but as time's gone on I feel I'm much more confident now. (Amy)
>
> So, I guess, um, working within what the schools got going, working with what your colleagues have got going, working with the syllabus, but then bringing what you have learnt over the years to the age level and the needs of the kids … I didn't take into account all of those things before, I just did 2+3, use your counters. (Gemma)
>
> I thought I came out with all the answers and learnt very quickly that I had no answers for anything. (James)

The level of support teachers receives in developing their PCK appears to vary. Participants described the support available in remote schools as limited and the support and opportunities available to teachers generally as highly variable from school to school, with some participants benefitting greatly from access to adequate resources, professional learning opportunities and mentors:

> It is so contextual … I'm not sure if the Department also has the same kind of, um, practice of graduates going to woop woop schools… I just wonder how much support graduates get when they actually land in schools. I mean, we support our graduates hugely here. But I think back to when I went to Meekatharra for my first two years, I had no idea what I was doing, and I didn't get any support from anyone up there, because we were all graduates, because that's the way it worked, so it was the blind leading the blind. (Claire)
>
> I was excited probably to speak to you, because I just don't feel, on the schooling front, there is enough, like PL opportunities for teachers, and I'm talking holistically from the state, Catholic and private sector, those teachers need more tools in their toolkit, and it needs to be ongoing … some people who are naturally wired mathematically and are passionate in a school with adequate resources and support et cetera, they're very fortunate, … talking to colleagues at different schools… they always say 'you have that there' then I'd say 'yeah, we're lucky'. But they don't, but they should… how can we improve the standards if we're not all equipped correctly… practical mathematical teaching workshops… needs to be ongoing, for every teacher…for their whole career. (Sam)

> I was very lucky for the first three years to have the same Year Six teacher… and she was amazingly influential in giving me the support that I needed to make sure that I wasn't consistently having bad lessons, …there's so many different things that go on, and so, to have somebody that was so in the know, um, it was something that I routinely put into my end of year reviews, in my second year and my third year, I really want the same support that I got in my first year, I really need to continue to have the support from this one teacher. Um, to the point where I'd done three years and I felt really confident in teaching that year level. (James)

Attendance at external PD sessions varied greatly among the participants, with those in an administrative role showing the greatest motivation to seek external advice in order to support their colleagues. Internal support was perceived as valuable by the participants, who indicated they benefited from: sharing ideas with colleagues; encouragement to try different approaches to planning or teaching; having specific members of staff they can go to when they have questions; meetings with a focus on how to improve; and PD organised by their school:

> The best thing is just to see what other teachers are doing, and there's not enough time for that, but over years I've seen 'ah, that works, that works, this doesn't, this doesn't' so I've sort of been able to pick and choose what I think works … I suppose, you get more used to … getting a gauge on what the kids are like … getting ideas off colleagues is always great. We share as much as we can… we have a pretty supportive environment. (Adam)
>
> There's some great mentors here, there's a maths specialist here that's really nice to bounce ideas off … I vent to my colleagues … more experienced colleagues that is, and they will actually give me help… I will vent because I'm frustrated because, I feel like I've covered this, covered this, covered this, covered this, and then I test and (laugh) there's been no change… in terms of the support, it's, it's been great. I actually implement a lot of the things that my, um, my more experienced colleagues tell me, and I actually find that actually it just helps me… I actually value really just the immediate support that I get. (Paul)
>
> At the beginning we were sort of like, asked to plan that way (making connections) and I was sort of like 'no' and then I started, and it's just like 'wow' it's another eye-opener … you actually think 'oh, something else

> new' (groan), and then you just see 'oh, wow' and a light comes on and it's amazing. (Rachael)
>
> It's one of those things that doesn't usually come to you, you have to go searching for PD if you want it … we've got head of department with maths and technology, so, if I did have any questions, or if there was anything I wanted to know, I could always approach those people, … in terms of support, I feel very supported because we do have those people that we can go to if we need it … the head of departments can bring those things to our attention, I find that really helpful, because it means that it just, it's another thing you can just think about as you're teaching and try and slot that in and it can just be a five minute discussion at the end of the session 'what words did we learn today?' What vocabulary? How would you use this?' … so, I think that that's been really helpful for me, just having those meetings where we talk about how we can improve, I find that that's really beneficial. (Amy)
>
> We have quite good PD that comes in, so when things happen or somebody notices something, they will do that, but I haven't accessed a lot of outside PD because, it's also, you're taking a bit of time off class, and that is quite stressful when there's not a lot of time anyway. (Zoe)

All the participants indicated that attending external PD was a personal choice influenced by reflection and their own motivation to seek these opportunities:

> I will actively pursue my own learning, whereas if you're not that way inclined you could possibly be very happy just to be doing the same old same old … I've always gone to the odd PD because I've been interested in maths … I'm very driven to improve myself, so I don't wait for people to offer something, I actively seek. (Claire)
>
> I haven't really chosen much (PD) in maths. Maths is probably my stronger point. (Adam)
>
> I have done PD when I've moved the year levels … when I moved from (Year) One to Three, it was quite a big jump … to … see what was expected of me, in junior school rather than the early childhood. So, I think it's a balance of what… I need a bit more confidence and guidance or new ideas, um, and then what the children need... it's really your choice and you just have to justify why you want to go to that… we look at… what our children need, and… where I feel I need extra help in that area to actually take it forward. (Rachael)

> It's not very driven by anything … it has to connect to the teaching standards, but it can be a bit quick, it can be a quick one-day course to cover the maths area … maths hasn't always been a priority, because I don't feel confident in it and so, sometimes, I don't have an interest in it or, yeah, I feel like I know what I know and I don't want to question it. (Stacey)
>
> My passion a little bit more is with the literacy side of things, um, so generally I will look at some of that. (Laura)

Stacey, who can lack confidence in mathematics, has sometimes felt anxious at PD sessions. Stacey remembered when she was at a PD:

> They were talking about arrays, and I don't remember that term from school, I don't remember being taught it, and so I had no idea what it was and that scared me. (Stacey)

Experiences of PD can vary for teachers, and they sometimes find that not all of the ideas that are presented work practically in their own classrooms:

> Sometimes it's really good and you can implement it straight away. Sometimes there's professional learning where I find that it will take a bit of time, for me, first to understand, and to see whether I can incorporate it into my practice … there's so much stuff available, but actually, sometimes it works, sometimes it just really doesn't. (Paul)
>
> Sometimes I feel like the people running the PDs have all these amazing ideas and it's great and you can implement them into the classroom, but sometimes they're not realistic when you've got 31 kids. (Laura)

However, Stacey also indicated that some PD had had a positive effect on her experience of mathematics education, as did most of the remaining participants. Learning from PD can involve being introduced to new resources, discovering new pedagogical approaches, developing the skills to be able to enjoy teaching the subject more; being given ideas with regard to engaging students in mathematics learning; or accessing assistance with planning and meeting student needs:

> I went to a PD with Paul Swan and he gave us lots of resources … lots of ways of explaining maths … starting at the language and then moving into games to explore and, and looking at mastery of things before you necessarily move to the next step, or write it down, or start questioning why it happens … so I remember that having an impact on what I was doing on a day-to-day level. (Stacey)

> I'm actually enjoying it … more, and loving it, whereas previously … It was quite mundane, and whether that was due to lack of resources. There was probably a lack of professional development. (Sam)
>
> We've had a few people come out from AISWA, just to talk to us about games, you know, playing games, and there doesn't always have to be a finished worksheet…sometimes the maths lessons that are the best and where the kids learn are…where they are doing a game, where they're really engaged, they're involved, but you might not have complete evidence of that, it's just sort of anecdotal evidence…that's probably the biggest one for me and that was a bit of a turning point. (Adam)
>
> The AISWA consultant (helped with planning) … so you're actually testing each student … to see what they understand, and then that says 'right, that's where I need to go'. So, and then we've actually got a big menu of all the different activities we could do, so like a planning menu. So, then we can pick and choose, so that has really, really been useful because it gives an exact place of where we need to start with what the kids know, what they don't know. So that's been, that's been extremely useful … puts you in that zone of where the children's needs are, and, I think that's where we need to be. That's where they need, where they need us. (Rachael)

Whether they attend formal PD sessions or not, professional development appears to be ongoing for the teachers, with much learning taking place through teaching experience and reflection, trial and error, and changes in role such as changing schools or year levels:

> (I) moved to Year One, and then there was all that growth there, and then I moved to Year Three. So, as I've moved year levels, you've grown within that… it's been vast with that movement, to my personal growth. (Rachael)
>
> I taught Pre-Primary for five years so I was a bit more relaxed coming into it, because I had a really good background and sort of knew exactly how I wanted do things. Because now, first year that I'm doing Year Two, even though I've been teaching for a long time, I think 'oh, that wasn't so great, won't be doing that' or, you know, still sort of learning … that's stressful within itself having a new year level, you've got to build your resources, you've got to learn the curriculum and things like that … how to deliver it in a way that meets their needs, or it just takes a while to work out, how many groups do I break them into, or how do I run the lesson and things like that … I really like the little ones, that's my real passion, so I had a lot of

> resources and, um, I felt I was quite set up, in that respect, um, and I , yeah, yeah, but going into the older year groups, then not as much, because, you know, all the games that I have that I've made, all the resources are way too, way too young, so I've got to, sort of, start that process again. (Laura)
>
> It's strange really because I feel like, sometimes, I'm experimenting on the kids as well … I look back at, even what I've done last year, and think 'oh actually no, there's actually other things that we could have done, I could have done better … it's still a work in progress … I know that I will need many more years before I can refine this craft to be effective. (Paul)
>
> Being in the classroom and actually teaching is where you get most of your experience … even now, you still have your terrible maths lessons, that did not work, and so you, you've got to look at and go 'I won't do that again' or 'next time, I'll do it like this' so I think just having those couple of years just to try things out and see what works and what doesn't, um, and I think experience is the main thing that kind of helps you to become more confident in the area. (Amy)
>
> I think, a really good thing is to move around. You get really stale in one spot. I know you build on it, … if you're in with, um, one age group, um, but it's really good to go up, you see what they're doing, and then you can actually apply that, you know, and vice versa. (Gemma)

In conclusion, learning and understanding mathematics is different to teaching mathematics. Learning to teach mathematics requires the development of specific pedagogical content knowledge along with a growing understanding of how to identify and build on a student's prior knowledge and experiences:

> I was really taken aback by, by how to teach it… it's actually a different way of thinking…they don't have those synapses yet, they don't know about this sort of thing. (Paul)
>
> I just could not access them at all. Like, I was trying to teach them fractions, which I now know is something which is just completely foreign to some of them ... it's an area of weakness - not because I don't understand it, because I do understand it completely - but it's an area of weakness because I don't feel like I'm communicating it properly … English I can teach really naturally. But mathematics I know is an area where I am not as strong at in terms of communicating my, my understanding of it to them. (Paul)

4.2 PRIMARY SCHOOL TEACHERS' PERCEPTIONS OF THE CONTEXT AND KEY STAKEHOLDERS IMPACTING CURRENT EXPERIENCES OF MATHEMATICS EDUCATION

The skills and understandings developed through mathematics education are generally viewed by educators, students, schools and parents as useful and important for later learning and life. The value of mathematics, for many of the participants in this study, related to the significance mathematics has in every aspect of our lives:

> Maths is needed in just about every other area that we're involved in … a lot of the time people don't realise they're using the maths skills they've learnt at school … it's a vital part of everything we do. (Michael)
>
> Maths is not just a, a subject that is completely devoid of any, any other subjects. It is part of everything that we teach … to shut down in Year Six is not okay, because you still have stuff to learn that you'll need for the rest of your life. (James)

The importance of mathematics and literacy in comparison to other primary school subjects appears to influence: how teachers perceive and experience success and accountability in mathematics; their working environment; and their students in mathematics.

4.2.1 Success and accountability

Teachers are required to follow the Australian curriculum. In terms of accountability and in connection with the value placed on both literacy and numeracy, these are the only two primary school subjects monitored by The National Assessment Program (NAP).This program uses national tests and international assessments to measure and monitor progress towards curriculum achievement outcomes and publishes results for the government, the education community and the broader community.

The participants in this study perceived that experiences can vary from school to school, depending on a school's focus on and response to NAPLAN testing and results. There was a perception that teachers are held accountable for NAPLAN results, though many of the teachers in this study did not perceive it to be a reliable test. While schools, students and teachers may be judged on their success in mathematics education through NAPLAN testing, the teachers in this study held broader definitions of success in mathematics and many of the participants experienced curriculum and reporting requirements as barriers to achieving their own aims in mathematics education.

To elaborate, some schools alter their teaching in preparation for NAPLAN testing:

> Some schools teach to NAPLAN, some schools teach to the curriculum, we teach to the curriculum here, and just are hopeful that what they put in the, um, in the NAPLAN is what we've covered in Year Two. (Laura)
>
> The school I was at previously, predicted NAPLAN results in about Year One…they did predicting tests…(identifying) what kind of results we were looking at and how we could impact them… in early childhood there is some value in those sort of assessments, but so much is happening developmentally, and children move so quickly, um, in big spurts, and then they sort of slow down for a while, but it's quite hard to predict where a child is going to be, especially, you know, the difference between a five-year-old and a six-year-old is quite significant. (Stacey)

Many of the participants in this study perceived NAPLAN testing as stressful for some students and also experienced pressure themselves. The pressure on teachers can arise from school or parental expectations, and from the perception that they will be held accountable for the results:

> I think it's a lot of pressure… a lot of unnecessary pressure. (Rachael)
>
> Parents put huge stress on their kids to get good NAPLAN results. (Michael)
>
> I've only ever taught Year Six. So, I've never actually felt the pressure of teaching NAPLAN, um, but I do feel the implied pressure of having NAPLAN results in Year Seven…that I'm going to be held accountable for their results next year. (Paul)
>
> You're building them up for NAPLAN, for the following year, in Year Three, so that's always in the back of my mind, that I need to make sure that I'm covering everything properly, because, even though they do it in Year Three, it's quite early in Year Three and everyone says, because I did it last year, everyone's like 'oh, it's not a reflection on the Year Three teacher, it's a reflection of the Year Two teacher', …it's just that little bit of added extra pressure. (Laura)

Although NAPLAN data are widely published, the multiple-choice nature of the test and the perception that a student's performance can vary from day to day depending on external influences meant that many of the teachers in this study had experienced the results as unreliable:

> A lot of NAPLAN is multiple choice, so, it's, you know, it's sometimes just luck of the draw 'I'm just going to tick this one', you know, so, yeah, so I'm not a huge fan of it. (Laura)
>
> I had a student last year who was, um, very, very low maths, very low, and actually was attending support lessons, um, and when her NAPLAN results came back she was right up there, like quite high, and I (laugh), look it could have been luck, I don't know, but it's just, it was, a couple of my predictions that I had imagined, whichever way it would go, weren't entirely accurate, so I do wonder sometimes, because it is obviously multiple-choice, and those things, I don't know if it's a great indicator of where the kids are at, and it's one of those things where, um, as I said it could go either way, you could have a student that's very bright that just doesn't perform on the day, so I think it's not a measurable assessment. I think you need to look at how they go over a range of different assessments, because it's, it's one of those things where you can't really measure someone's progress in one day, it kind of has to be a whole, over a whole period of time, to see how they're going. (Amy)
>
> There seems to be a huge emphasis on NAPLAN, and I just feel we're teaching children, and if they're tired or hungry or unwell, they're not going to perform. So, there's a lot of pressure, in the primary years, to get the best results possible, but children are children, so if they are not 110% in the zone, of course it's going to impact data. (Sam)

While schools can be judged and compared based on NAPLAN data, success in mathematics education can be viewed in different ways. For the primary school teachers in this study, examples of student success in mathematics included students reasoning effectively, obtaining skills for life, growing in their knowledge or understanding, or developing and maintaining a positive disposition towards mathematics:

> On a success front, we are able to push sort of the highflyers of the group with real-life open-ended questions where I expect that mathematical reasoning to be really thorough… I believe it's one skill to have that automatic recall, but… a good mathematician can articulate the steps in that thinking process … I have Year Twos, they are in a schooling system for a lot longer, so if I can change their attitude, whether it's to themselves or to

> what they're actually doing, then I feel I've done my part… They don't have to love maths, they just have to be open to maths and open to making mistakes and knowing that it's a safe place to make mistakes. (Sam)
>
> Anyone who's got a severe special need, you know, stepping away from the curriculum and saying, actually, they need to know money… time… timetabling and schedules, and some banking, like to me they're the sort of goals for a child who's not conventionally meeting the curriculum in mathematics. (Stacey)
>
> There's nothing better for a teacher than when a child shows that something has shifted in their thinking … (when they don't shift in their thinking) That's tough … I worry about that … what I'm really interested in is evidence of growth … we have a focus in our school of everyone is capable of improving and it's where you start from, that's your learning journey. So, we're not trying to make everybody the same, because that's just not realistic. (Claire)
>
> I don't expect every child to be at that high level, or, um, there is going to be kids that are going to need that extra support, but as long as I can see that they are making progress, I mean that's the main thing that I aim for. (Amy)
>
> Trying to get the kids to enjoy mathematics would probably be the biggest success because it is one of those subjects, as I said, you've got half that love it, half that don't, um, so it's one of those areas where, trying to find that enjoyment in it, and realising that it can be widespread, and obviously trying to make the kids aware that it is going to be something that can be applied to real life… (that) it's an important subject. (Amy)
>
> The successes are, every time a kid goes 'Aah' and goes 'yeah I get it' or, that a kid even puts up their hand to answer question in maths that I have been struggling to get to answer any questions. Um, any time that a kid feels confident, any time that a kid feels, um, challenged but not that a task is impossible, that's a win. (James)

In particular, the findings revealed that within a primary school context, there is a strong focus on preparing students for later learning and life:

> It needs to be fun in a primary school setting. You don't want to set those kids up who are really, really maths strugglers to enter into senior school or high school thinking they're no good at maths. (Adam)
>
> You try and prepare them for life, or, or to be learners, so if we've, they've missed something that they can then figure out how to learn it. (Zoe)

> It's important that they know how to, perhaps, handle money, tell the time … all the things that are going to help them in a day-to-day, in life. (Gemma)

None of the participants perceived it to be realistic for every child to achieve set levels of attainment:

> We're nervous about having statements like '80% of the Year Five cohort will reach this benchmark or this stanine'. I don't think that's realistic. I think that sets you up for failure, and it puts a lot of pressure on students and parents, and I think it gives the wrong view to parents that that's what is important. (Claire)
>
> I think you can try your best to help every child succeed but there are just those kids that are on the lower end that have other issues that just, you know, it's going to take them time to, they might succeed in small parts in some areas, but overall to be at a standard level, no. And that's not through fault of their own, I think of how much, because these kids are going to support, we're creating experiences that at their level, things like that, they just, if you've got dyslexia and the words or the numbers are jumping around on the page, that's going to be really difficult for you, so things like that, or processing issues. (Laura)

Regardless of how a teacher views success in mathematics, teachers in Western Australia are required to teach, assess and report in accordance with the Australian mathematics curriculum. The curriculum provides guidance on what to teach, making expectations for each year level clear and providing structure for teachers. This structure can be experienced positively, providing focus on aspects of mathematics education that match teacher values, as well as providing guidance on what to do to fulfil their duties in preparing students for later learning:

> I love the proficiency strands. I think that's… an absolute strength of the curriculum. (Claire)
>
> The way that it's set out in the curriculum is fine, there's enough elaboration in there, and it's open and broad enough but specific to know exactly what to teach, um, but broad enough to be able to work it in your own way. (Paul)
>
> I really like the Australian curriculum with the language component of maths. Um, I think it's nice that they've acknowledged that mathematical language needs to happen, and it needs to be given attention. (Stacey)
>
> The way they've got the overarching standards of numeracy, and that kind of really reminds you that that's the big ideas and that's what you should just

> be having like seeped in every lesson … you should be always aware of it, but it's not something that needs to be explicitly taught, it's just there to kind of keep you on the right track. (Stacey)
>
> I know by the end of the year, as long as I've ticked off everything on this ACARA document, or this SCSA document, I've done my best to make sure that I've taught these kids everything they need to know before they go into middle school. (James)

In addition, there are aspects of curriculum requirements and the focus on testing that can be experienced negatively, restricting a teacher's ability to tailor their teaching to the needs of their students or to show what their students are capable of:

> The student is only as good as the test they take… the curriculum is quite rigid…I think they can be learnt at different paces and we've got to really try and feed off… what the students' strengths are and then they can probably try and fill in those gaps. Because maybe they're not mature enough to really understand some of those concepts yet. (Adam)
>
> We sometimes think and place too much ideas about getting them up towards a particular score in a test, um, and that, that I think changes the way we teach as well. It changes the way that teachers approach the subject, and I think that that diminishes how much you can actually, um, you know, make your students enthusiastic about mathematics…going to then just teach mathematics in that sort of rote way I feel… I don't teach like that, but occasionally I will still feel 'well, there's a NAPLAN result next, next year'… then you're focusing… on the wrong things for them, you're focusing on them achieving a particular score in a test… all you're doing is then just teaching them about the formulas…and you're losing… all the wonderful stuff that comes with it… I think if we were less sort of focused about testing… then we could… actually start… building their, um enthusiasm. (Paul)

Some participants experienced the compulsory grading of students on a 5-point scale as somewhat thwarting their efforts to improve student dispositions towards mathematics. They perceived grades as a type of labelling, with associated negative psychological effects, and not 'fine-grained' enough to clearly convey progress:

> The grading A to E… for a lot of students who've had a journey in school of failing maths, have had D, D, D, D, D, D, D, well, they are pretty much being told that they haven't progressed… we have to find ways… at

saying…'I can see that you've improved' but, on paper and especially for parents, often it's just not fine-grained enough... it looks the same, and that's devastating. (Claire)

If we're giving each student a mark in maths … it's not really giving them justice to show off what they can do in maths … you don't want to set those kids up who are really, really maths strugglers to enter into senior school or high school thinking they're no good at maths. But … at the moment … that's what we're doing by providing them with an A, B, C or D, you're labelling kids … there's not much we can do about that, the system kind of governs what we do and we just have to go along with it. (Adam)

The government mandates that students receive a grade. I think, sometimes you need just to reinforce to the parents, and to the students, it's not the grade on their work that counts, it's the comment that's written on there, that reflects the journey that they're making. (Michael)

Adam also described how the perceived need for marked work can impact on how much he feels he can implement certain teaching approaches:

> Game-based play is great, but at the end of the day we still need to have a grade for maths and the only way to have that grade is to have some evidence, and anecdotal evidence is good, and teacher judgement is good, but it doesn't always fly with some parents … you get a lot of parents who, you know, expect a finished worksheet. (Adam)

Three of the participants - who taught Pre-Primary, Year One and Year Two - felt that the mathematics curriculum was manageable. However, when speaking about this the Year Two teacher, Sam, indicated that the ability to integrate mathematics with other subjects helps to make it manageable:

> It's very play based, and it's very, in early childhood it's very rich. And so, you get to really sit in the knowledge, it's not moving too fast, they really get to build their own understanding. (Stacey)
>
> We, as primary teachers, are really clever and we can integrate things and I think 'gee, we're lucky to have that ability'. (Sam)

The remaining participants all described the curriculum as crowded and experienced having to move on from concepts before they would like to, or the feeling of rushing through content, as a result of being time-poor:

> Maths is a big one that I find that I just don't know if the kids get enough meaningful experience time with certain concepts … sometimes I feel with the curriculum that we're just, we're really rushing through everything, so, um, what generally happens is some concepts that I feel we should be spending more time on, however, we need to just keep moving through, so we get through everything … there's nothing worse than having to move on from a concept knowing that you haven't quite got all the kids there, and that's a really tough thing … it means we have to do the content, do an assessment, and then, you're kind of giving them an assessment, you feel like it's almost not right, because some of them aren't ready for it. (Amy)

> As primary teachers we're lucky, we can integrate other areas together to sort of multitask, but, even then, you're still struggling to get through everything … It's a crowded curriculum. You know, there's more coming into it all the time, and sometimes you just, you run out of time, literally … as the teacher in charge of STEM at the moment, I sort of talk to the other staff about how they're going with those areas, and everybody says the same thing, the curriculum's just crowded. Trying to get through everything becomes a battle, and sometimes you just have to accept, well, we've spent two weeks on this, we have to move on. (Michael)

> I probably feel a little bit more pressure to get things done than what I did in the earlier years. I felt like you had a bit more time to really sit and develop the concepts and recap what they didn't do so well, implement those fun experiences … as they get older … you've got more things that you need to cover and less time … you're just constantly chasing your tail, yeah. It's just, you know, it doesn't, yeah, it doesn't get easier as they get older, I feel like it gets worse … this year and last year, I'm in the upper end of junior primary (Year Two). So, and then previous years I've been down the lower end. So, I think, even though they are junior primary, it is a little bit more formal and I feel like the curriculum is a little bit more jampacked of what we need to teach them. (Laura)

4.2.2 The impact of the working environment

Teachers' experiences of mathematics education were found to be impacted by their working environment, in particular: school timetables, structures and routines; the pedagogical approaches promoted by the school; requirements for consistency between classes; and the suitability and availability of resources.

To elaborate, within the school context there can be timetabling requirements which may contribute to a working environment in which teachers feel time-poor:

> We do have children who are pulled out for music or pulled out for various appointments. So, sometimes, to have all the children in one place and, it's a very busy place to be. So, that depends, from a maths perspective that's a challenge, but from a holistic perspective of the child they're given incredible opportunities. (Sam)

The ability to integrate mathematics with other subjects was valued by those who could do this:

> We try to integrate in an authentic way because I think that's the key to getting through the content. (Claire)
>
> We try to use what's in the maths curriculum and apply it into other learning areas, so that they're getting that extra practice, because the maths curriculum kind of just gives you an outcome but it, you know, it's, it's kind of how you're going to incorporate that into learning and actually have some hands-on opportunities for the kids, whilst remembering that you only have a certain amount of time. (Amy)

However, mathematics can be isolated or integrated across the curriculum, and some teachers faced barriers to implementing an integrated approach such as not consistently having all of their students in the same place at the same time. This can be due to streaming or students leaving the classroom for support, extension or other activities:

> I'd like to see a lot more of it … such a great way just to be able to teach everything in the same sort of, time efficiently … However, I can't do that in my maths group (streamed) because it is a specific maths group. (Paul)

In addition to aspects of the working environment creating barriers to integration, being time-poor also means that teachers can feel unable to integrate. Reasons indicated included: the time it takes to plan for integration between subjects; and the perceived need to go through mathematical concepts and skills explicitly, but not feeling they have the time to teach via an integrated approach as well as explicitly. As such, most participants experienced the majority of mathematics education as isolated rather than integrated:

> Science is always the straightaway link … it definitely takes time to sort of plan how the maths is going to connect in … I feel like sometimes we do plan maths very separately from the other learning areas … If you're learning about … Anzac Day… (and) the maths counters are Anzac themed. That's, to me, not integrating, that's just a nice link that makes…the kids feel like it all connects … I do think it (integration) happens, I just think the majority of your maths work happens separately to an integrated approach. (Stacey)
>
> There's definitely levels of maths in everything, but, it's not as integrated as other learning areas are, just because it's got quite strict rules and you do need to explicitly go through some of those skills. (Stacey)
>
> Most of it is linked in … however, some of these kids actually do not see it as that connected thing and so they still need to actually be taught these separate things, which means it's huge … there's just not enough time. (Paul)
>
> I feel like maths is a contained area. (Gemma)

Different schools encourage different pedagogical approaches to mathematics education, in line with the individual school's focus and values. For example, some schools expect teachers to use provided textbooks or to teach explicitly, while other schools may promote an enquiry approach. These different working environments significantly impact teachers' experiences of mathematics education, affecting the teaching approaches they adopt and how well their practice aligns with their own beliefs and values:

> Maths was a huge focus at the college last year, and we are also doing… visible thinking, so I think with having people like the AISWA consultants come in and give us, and Pinterest… especially in the early years there are so many ideas through that… open-ended tasks… mathematical reasoning… no right or wrong… the journey to get to the maths is actually more important sometimes than that final result. So, to unpack that thinking 'what makes you say that? Prove it'. (Sam)
>
> At my previous school it was more of a textbook base … quite boring … sort of rote learning … there was no … pre-screening of the students' abilities, so even if … just an example addition, if the class had addition or 95% of them had that, they were still doing the same things … whereas here I tend to find that, um, it's more about the process rather than a filled-out textbook …

> we're always told it's more about the proficiency strands … the problem-solving skills, they're probably more important than, you know, knowing area and perimeter … it's more about the process rather than getting the correct answer and … students at this age are learning to learn … if they know the process … then they can apply that in other areas. (Adam)
>
> The school's got a focus on visible learning, and a focus on enquiry, that's had a massive impact, and that was part of their strategic plan was to make those things happen more, so that's had an impact, just on the planning documents we use, the resources we have in our classrooms, the way we put up displays, and so all of those things sort of trickle down into my practice … definitely different school to school. This school has a big focus on enquiry, um, and on questioning and understanding. In my last school it was explicit education was the big focus and that took away from hands-on at times, um, it was a Pre-Primary class and I had a lot of PowerPoint presentations to introduce topics rather than a hands-on experience, and that was a very different way of teaching, um, and that took away from my own pedagogy of 'maths should be hands-on in the early years and written after you understand it physically'… I think every school approaches maths in a really different way, and accepts different things, and it, yeah, definitely will have an impact on the way I teach. (Stacey)
>
> Teacher accountability, as well, is huge… if maths isn't valued in the school the staff won't value the maths. If the staff aren't held accountable for good quality maths teaching, then, they close the door and, really, what's happening within the class? Are people differentiating? What does that look like? (Sam)

Within many metropolitan primary schools, the working environment may include more than one class of each year level. In these instances, the school may communicate and monitor expectations regarding consistency between classes. Implications for teachers include an increased need to communicate with colleagues, an increased ability to meet student needs, but also some restriction on teachers' choices:

> Making sure that the three Year Five classes are kind of linked … when it comes to assessment … it's always nice to have things that are really common … you've got to keep touching base with your colleagues. (Adam)
>
> The collaboration and the consistency across the year levels, so, we plan together … it means that we can do some really good grouping, we can

> extend the high-level kids in really authentic ways, we can also remediate for skill … we do mixed ability grouping for different activities … that's part of the (strategic) plan of the school is to have, you know, more collaboration, more, kind of, just stability across year levels so everyone is consistent. (Stacey)
>
> Our assessment pieces all need to be exactly the same … that's how we moderate and do things like that so, it's kind of a bit hard to stray and do other things when we've got to come back to, to the same thing. (Laura)

These restrictions are partly due to teachers not having enough time to both implement their own ideas and meet the requirements necessary for consistency. Even if a school does not have multiple classes of each year group, it will generally have a body of staff with varying experience. Another way to promote consistency among classes is to provide a textbook for all of the teachers to use:

> (The books) give a structure… we've (the staff) got a huge range of experience and we need to make sure that everybody is covering the same content. We might cover it differently but were covering the same content. (Michael)

The resources provided by schools vary and this aspect of the working environment also impacts teachers' experiences of mathematics education. Resources in the context of mathematics education include textbooks, manipulatives, human resources and digital resources. Textbooks appear to vary in terms of quality and suitability, with many participants perceiving a silent expectation for the textbook to be completed if it has been purchased:

> There are some beautiful maths programs available for purchase and schools purchase them and think, and then, not enforce them but, have an expectation that you will use them wholly, and that can be a huge barrier, if the program's not suitable for your year level or not perfectly matched for your curriculum. (Stacey)
>
> As soon as you purchase a textbook, there's a bit of a… silent understanding that, um, it has to be done … here there's no sort of textbook so… we try and have authentic pieces of learning that the students can kind of guide through. Doesn't always work though. (Adam)
>
> We have the iMaths books, so, I hated them in Pre-Primary, I thought they were just, like, I did them because we had to… they're just very, not very

challenging … the books are a bit better in Year Two, I find them a bit more challenging … I do what the program says. Obviously if I think the kids are, need extra help, then I'll do other stuff. But yeah, so I go by what the program says, and they have, there's a few bits and pieces that they've skipped, but I think the expectation is, if a parent buys a book, they expect it to be completed by the end of the year …but it (the book) can be a little bit bland as well, I think, yeah. That's why I try to incorporate a little bit more hands-on things as well. (Laura)

The program that we use sometimes I dislike, which is, um, the maths program that we're currently using. I find that it can be a little bit confusing and sometimes when you're trying to teach one concept, they'll introduce a whole range of other concepts, which can be confusing for the kids … the program that we're using is, um, obviously quite a bit of bookwork, so I kind of like to try and incorporate hands-on activities. (Amy)

Manipulatives were perceived as important for learning in mathematics and these can also vary in quality, availability and suitability:

I was at a different school … in upper primary, and that school was entirely different … an under resourced school. So, a lot of things we had to create for ourselves. (Sam)

Some schools process of taking things, borrowing things, is so, cumbersome or lengthy or time-consuming, whatever you want to say, that sometimes you just think I'll just make do without it, and move forward without whatever it is ... the process of buying consumables, perhaps, um, might be, not here, but might be made difficult, um, so you just buy it yourself, or once again if it's too expensive you just do without. (Gemma)

I think because hands-on is so… important, you do need to have a wide variety of resources, not just have one set of something that gets shared. (Stacey)

The human resources available also impact what teachers can achieve:

In the younger years you've got that constant help, so you've got one EA that's there to help do your resources, and as they get older you lose, get less time with an EA and you've got to do a lot of that stuff yourself, but then you become more time-poor because of the stuff that's in the curriculum. (Laura)

> At one school … I think you could probably only get a quarter of the way through the maths lesson because it's, you're crowd control, pretty much, so it's behaviour management. Yeah, so, a hundred and ten percent, I think the area the school's in and how much support staff you have in there is definitely going to make a difference. (Laura)
>
> You need to have another pair of hands, physically, you need another adult there to help you (which you have in Year Two) but any further on and you don't. (Gemma)

Many of the participants spoke of the benefits of using technology and used digital resources to engage students, to help explain concepts, to differentiate learning, and to provide feedback to students:

> Having interactive knowledge is really good, just having videos that explain big concepts, um, so that I can watch them and then explain it … there's an iPad app where you can draw different mathematic problems and it finishes them for you and fixes it if it's not correct, that's been really huge as a teaching tool because it means I can give it to people, so digitally there's been some amazing, amazing progressions. (Stacey)
>
> With the use of technology, it's really easy to differentiate with certain things … it is sometimes tricky to, when you see kids who struggle with maths, um, is it the reading or is it, um, is at their maths? … but with technology those sorts of things can be overcome. (Adam)
>
> We can be really clever in our delivery … things like YouTube clips initially that you choose to hook them in, to captivate them. (Sam)
>
> We've got, you know, reasonably good resources, and, with the Internet these days, everything's only a few mouse-clicks away, if you're unsure of something. (Michael)

4.2.3 Teachers' experiences and perspectives of students in mathematics

As mathematics education is highly valued, with high stakes on outcomes of literacy and numeracy compared to other primary school subjects, teaching in this context involves addressing levels of student attainment in mathematics. The findings show that the teachers' experiences of students in mathematics include a wide variety in student responses to mathematics.

The participants in this study perceived there to be a very wide range of student abilities in mathematics, with student engagement, confidence, anxiety and mindset also varying. Some participants perceived that there are students who do not see the relevance of mathematics and, in order for students to succeed, all participants described employing strategies to engage students and to build student confidence. Strategies to meet individual student needs in the classroom included the use of diagnostic assessments, changing teaching approaches, purposeful encouragement, the use of hands-on learning experiences and games, organising the class so that needs can be addressed individually or in small groups, and creating opportunities for peer learning. In addition, teachers reported students needing support or extension leaving the classroom to work either individually or in a small group with a specialist support teacher or Education Assistant (EA).

To elaborate, the teachers in this study recognised that some students do not see the relevance of mathematics. These teachers also believed that students need to see the relevance of mathematics to engage in a lesson, with student engagement necessary for learning to take place:

> When they are struggling with a concept, it's often because it's totally irrelevant, they don't see any connection to anything … it's just constantly trying to make those connections from the mathematical concept to real life and their own experiences. (Claire)
>
> The challenges, as we spoke about before, are those kids that aren't interested, they don't see, um, the relevance. So, the challenge then is to try and make the material more engaging, more relevant to them, to try and turn them on with it … I've got a couple that, you know, really enjoy maths, so they, they pick up and they're more enthused by what's going on. Those that don't like the subject, sometimes it doesn't matter what you do, you could stand on your head, and … all sorts of stuff and they're still going to be sitting there going 'oh, it's maths'. (Michael)
>
> A lot of its maths vocab, getting the kids to actually understand why they should be doing this…the challenges are just in getting kids engaged. (Adam)

The teachers perceived student confidence to be important in mathematics education:

> If the children aren't good at maths they tend to, sometimes they say 'I don't like maths because I'm not good at' so it's that building their confidence. (Sam)

> I just feel that maths is a lot of confidence with the kids. (Rachael)

Some participants explained how it can be challenging to recognise student needs if students are afraid to ask questions. Reducing student anxiety was perceived by the teachers as important to foster engagement. It was widely recognised that just the mention of mathematics was enough to trigger anxiety in some students, which can then shut down the possibility of learning:

> The interesting thing with mathematics is, I mean, I've pretty much got the kids on board now, but sometimes you'll find that kids will not ask for help, so they'll, they'll kind of sit there and say they can do it when they can't, so it's one of those things where sometimes kids are afraid to actually, um, say like, 'I'm not understanding this' so that's probably, um, where, like I kind of notice, that's probably one of my concerns is when, um, when I notice that, and the kids aren't coming forward… if you are not aware of it, they can go through, doing the maths, and by the time you realise they haven't understood something, you're already getting close to moving onto the next concept. (Amy)
>
> (Anxiety) shuts down any possible way of, of opening up to thinking about something new. (Claire)
>
> As soon as you put maths up on the board or you speak about maths, I think some kids start to worry, just with the idea of it… (they) just put up a bit of a mental block, and that's the biggest challenge for me, I think, how can I make this lesson where they get something out of it? (Adam)
>
> They'll just be paralysed by it, and, not by anything more, but just the idea that we are doing maths, will just paralyse them. (Paul)

There is a focus on understanding, reasoning and problem solving in mathematics education, in addition to fluency. Building understanding can take time, reasoning requires critical thinking and problem solving can require perseverance. Some students may be willing to engage in quick mathematical tasks but not have the disposition to develop all mathematical proficiencies:

> (I'm) getting a lot of students who want instant gratification and they're not willing to work towards something and that while it is not necessarily about getting it right or wrong but seeing the, seeing what you did to get it to that … kids just don't see that, they just want to get it finished. (Adam)
>
> That whole idea of doing multiple steps to get an answer is really hard for kids, because that's not the world that they live in, because you press buttons

> and things happen… most children now are very funny about that if they don't get an instant answer, they're a bit freaked out. (Zoe)

A student's beliefs, attitudes, anxiety and expectations can generate failure in mathematics education and this failure can be pervasive. Many of the participants observed how student's self-perceptions, as learners of mathematics, effects them outside of the mathematics classroom:

> I think maths is very much linked to self-confidence, your self-esteem, your emotional well-being, across everything. (Gemma)

For the participants who spoke about this, most described how students' negative perceptions of themselves in mathematics can permeate into other areas:

> If a student labels themselves as being useless at maths it seems to permeate then into all of their learning. So, then they seem to think that they're just no good at learning anything. Whereas if a student sees that they're no good at writing it just seems to stay there with writing, it doesn't seem to have a spreading effect on their whole sense of themselves as a learner, and I don't know why it is that maths does that. (Claire)
>
> Kids seem very hesitant to have a go in maths, whereas they will in other areas … there's something about maths and if you don't feel good at maths it makes you feel stupid. And, I can't tell you why, but there's something about being good at maths means you're smart, being bad at maths means you're stupid … it goes across, it sort of seems to leak through everything else. (Zoe)

One participant described how students' positive views of themselves as mathematics learners can also permeate into the rest of their learning:

> It can be a really good area to help try and engage a student back in their learning if they've become disenfranchised. If they can experience success, then other areas they start to put a bit more effort into, um, particularly science, and a lot of the social sciences with mapping, and things like that, if you can get a connection between, get success in maths, you can get it to bridge across. (Michael)

The participants who spoke specifically about student mindset experienced overcoming fixed views as challenging, if not impossible:

> The older they are, the more ingrained that mindset has become … a lot of parents will say ‘I was hopeless at maths’, and so then that’s what their children are hearing all the time and so they just come in with this sense of ‘well, mum and dad weren’t very good at maths so it’s probably, you know, that’s my lot’ and it’s darned hard to shift. (Claire)
>
> Some of these kids have had, been in that bottom group for a very long time. So … You can’t even change that mindset. (Paul)
>
> Some parents are very ‘oh, I’m no good at English, I’m no good at maths, I didn’t get it, I don’t see the need for it’ and that just rubs off on the children, like any parental attitude will rub off on them, so, it can be a real, real barrier for some kids. (Michael)

All the participants indicated they felt it was necessary, within mathematics education, to employ strategies to either overcome anxiety, build student confidence, engage students and/or turn around student attitudes. For example, as part of her attempts to build student confidence and encourage a growth mindset, Claire plans work to clearly link concrete, representational and abstract, focusing on their critical thinking skills ‘what can you see?’ because that is non-threatening. In terms of student responses to her efforts, Claire has found that it is important to be both explicit and patient:

> Initially they’re a little bit confronted by it, and probably suspicious of it, and think ‘no, that can’t possibly be, I’m hopeless at maths’ but then over time, and I think it’s a drip feed…recognising and noticing and naming their successes, ‘see you persisted with that, or you tried a different strategy, or you could see that pattern’. So, it’s actually being explicit about what they’re doing so that they can then internalise that and go ‘oh, yeah, I did have a way forward’. (Claire)

Sam hoped that the children benefit from her “positive can-do attitude and, if we make a mistake it’s okay, that’s how we learn and grow” (Sam) and she described organising open-ended tasks to provide choice and student ownership, as well as “being a little bit more over the top with those kids to say ‘you know what, I’m so impressed’ you know, to honour, to steer them in the right direction” (Sam). Adam felt that the experience can be quite daunting:

> Because you’re not really sure how, how do, um, how do I get those kids engaged? … that’s probably the biggest, um, the trickiest part for me … I

> want to try and keep it fun, but there's a fine balance between fun and, I suppose, silliness and being unproductive, so you've got to juggle that, which is really tricky. (Adam)

Many of the participants associated the possibility of students experiencing fun and enjoyment with mathematics education, especially when hands-on learning experiences and games are involved:

> I like it to be fun … I really want the children to enjoy the counting and, just to develop confidence. (Rachael)
>
> Maths is not my forte, so if I'm being honest, I feel much more comfortable teaching things like English … I'd like to think that I, you know, obviously help them to be enthusiastic and motivated, um, so, I do try to, I suppose that's where I try to bring in things that are a little bit more fun and, you know, we watch a few little videos, we talk about things, and we do hands-on stuff, so I try to apply to all the different learners, like the kinaesthetic, visual, try to go down all those paths … I feel with maths, I like, if, if you have really positive, like if you're having a really positive outcome with the kids and you feel like they're really engaged, I feel like it, it actually kind of, it makes you feel more positive about teaching it, so, um, I suppose that's why I try to incorporate a few little games in there, so the kids are enjoying it. (Amy)
>
> I think a lot of kids when I say maths are like 'argh' like 'oh, do we have to?' so I suppose trying to change that and make it a bit more fun, bit hands-on and just, um, allowing them to be successful. I think when they've got hands-on stuff and they're, um, playing games and those types of things, they're a little bit more successful and it builds their confidence a bit more, so when it comes to the written stuff, then, they're more willing, and they're more, you know, a bit more confidence to give it a go. (Laura)

As students can vary in their interpretation and understanding of mathematics, and therefore their responses to mathematics education, the lived experience for primary school mathematics teachers includes a need to work hard to meet individual needs. Many of the participants in this study described employing strategies to work with small groups or individuals:

> What I try to do is generally try and group the kids together, because, yeah I sometimes feel if I go up and assist them individually, they can sometimes get frustrated and upset, and sometimes, you know, kids can get a bit

> emotional, where as if they're in a group, and we're talking together and we're doing it together, I feel like that can take a bit of pressure off because they don't feel like they're being, um, isolated, or that, they've got others around them and they're all working together. (Amy)
>
> We've still got a book that we use, which has activities in, and like, for example, the investigation, there are half a dozen topic pages that we need to work through, so they can do the, so they have the skills to do the investigation. So, we will work through them. But that's a case where, my top four or five kids, 'okay guys, you're working on this, off you go' and they'll go and work on their own, and I zip in and out, look and see how they're going, the middle group I get started and get them going, and the bottom, those who struggle, I spend most of my time sitting and working with them and going through it piece by piece, to try to, to get them up to where they need to be. (Michael)
>
> They're the kids that are, like, you're talking on the mat and they're not focused, they're watching or they're, like, pulling something on their shoe or, you know, so, for them to have that small one-on-one, small group, for them is really important. (Laura)

Within mathematics education, all the participants experienced a very wide range of student abilities:

> We do have a real tail-end and we have these highflyers. (Claire)
>
> The children who present come in, very unique, with different strengths and weaknesses. (Sam)
>
> Right now I've got one student who is working at probably at Year 10 level, and then I've got some kids who can't count on from 5 to 10, so you've sort of got that big range. (Adam)
>
> The challenges with maths is the ability of kids to be able to quickly grasp, need repetitive teaching, or not grasp a concept, from one given lesson, is so diverse that that blows my mind every single time I do it, so that's a challenge for me. (Gemma)

It was indicated by the teachers in this study that the wide range of student abilities in mathematics contributed to the complex challenge of teaching mathematics:

> I do feel a little bit lost sometimes … and that gets me a little bit nervous. Am I extending those kids enough, and am I catering for the, um, students who find maths really challenging? … it's a bit of a juggling act. (Adam)
>
> I think that it's probably one of the hardest subjects to teach, because there's such a range of abilities. (Paul)

Many of the participants experienced the use of assessments as helpful in identifying student needs:

> Those pre-assessments are gold, because they're so insightful, so we know exactly who we're targeting … we see that range … so although they're mixed for fluency tasks then, the children who come to me are always of a similar ability so that I'm working within the parameters to challenge or support them. (Sam)
>
> We've just done on entry assessment, and so that was really interesting to see where the children are at here, because then we see that and then we go further … you can also just pull from those groups as well if they're mixed ability, if you want to actually work one-on-one with someone. (Rachael)

Some participants spoke about anticipating student responses when planning mathematics lessons:

> We start of a big block on that (fractions) next term… I know already, I've got a couple who are not going to grasp it, so I'm already sort of thinking 'okay, what have I done in the past? What haven't I done for a while that maybe we could try? Where am I going to look for something new that might clue some of these kids into what's going on?' (Michael)

Many participants experienced peer learning as beneficial and described how they create opportunities for this to occur:

> With the grouping (in class) they're mixed ability groups so, you've always got those who can read and can do, and sometimes they're a better communicator with their own age group than I am … so you have that peer learning as well. (Rachael)
>
> The other thing that I find really, really beneficial is peer support. So, I've often, I've got a lot of really helpful kids in the class that often are more than happy to go and sit with one of their friends and help them, and that's just so beneficial for kids. (Amy)

All participants in this study experienced some of their students leaving the classroom to work either individually or in a small group with a specialist support teacher or EA, as required:

> If we've got students who are struggling, or that need to be extended, they can go out within a small group. (Rachael)
>
> So, we've actually got sessions, we've actually got, um, a student support teacher at the school who takes some of the kids out for different areas and maths is one of them … they get that extra support where they do some of the basic, core skills in that time. (Amy)
>
> We have support teachers here, so they take the children out, the ones that are really weak or not achieving, you know, at standard, they get taken out, um, four times a week and do literacy and numeracy … so quite often, um, when we're doing maths, they'll get taken out to do maths. So, they'll be doing more of the foundation skills, whereas, the activities that they're doing in the iMaths book would probably be, you know, some they would be alright but it would be a struggle for them. (Laura)

The teachers described employing many available strategies in an endeavour to meet student needs, and indicated that no single approach to mathematics education would be successful for all students:

> You can be as, be as great with this enquiry stuff, but really some of them just need that explicit direction. (Paul)
>
> There's not one way to teach something. There's whatever way works for that particular person. (Michael)
>
> I've found that it's quite interesting looking at Jo's belief system around 'everyone can improve in maths, um, and reach high levels' but then when you look at the, and that she feels very strongly that 'they should not be taken out of the regular classroom' but then you look at the gifted and talented body of literature and, you know, proponents of that and they say 'no, gifted kids need something quite different'. Um, and so, and then all the other research that I've read around grouping of students for maths is that it appears that the best way is to keep them in a heterogeneous setting but where the range isn't too extreme… it's been a bit scary to be, I suppose courageous to go down that path, because, um, because there is some conflicting research. (Claire)

Teachers can experience concern in mathematics education when students do not achieve expected outcomes. When this happens, the teachers in this study perceived a need to wait, or expressed a preference to focus on individual growth:

> I'm always really concerned when the kids don't understand the concept when it's been physically done in front of them … the other big concern is when they can do something but they can't explain what they've done … they've been rote taught … sometimes in early childhood, developmentally, it is about waiting. (Stacey)
>
> A lot down this end is because I don't feel their fine motor, their strength is not ready. It's sort of the writing of the numbers. So that, that would be a challenge … fine motors going to develop when they're ready. And if they can't write numbers in Pre-Primary, I know they will write their numbers by the end of Year One or Year Two … I don't think we should actually force. (Rachael)
>
> Unfortunately, we are told that they must meet this level. It's not so bad at this school because … the economic, um, I don't know what it's called … we will meet there, but, for other schools, I mean, that's hard … sometimes … you need to be patient … maybe those connections will be made later as well. (Paul)
>
> This is probably more so for the younger ones, but sometimes maths is something that, um, you know, kids might not get, but then later on it might just all come into place, um, for them, so as long as I can see that they are developing and they're progressing, um, then that's the main thing. (Amy)
>
> When you're getting students up in Year Six who you can't, um, line up decimal numbers, because they just don't see the relevance of the decimal point, it's like, well, that's a concept from many years past, why have they not got it? Why has nobody picked up on it before? Why has nobody done anything about it before? And that, you know, that prompts concerns … Some you can (turn around), others you then start to go back through report data and you realise that this problem's been there the whole way through and they just, for whatever reason, cannot get it … I think if you try to get each student to a set level, you'll drive yourself crazy, you'll never get there. Some are going to manage it, some won't. Um, you really have to look at each one of them as an individual and go, okay, as long as I can move them forward, then I'm doing my job. The more I can move them forward, the better I'm doing my job. (Michael)

Teachers play an important role in student learning and a teacher's beliefs, attitude, expectations, PCK and lesson preparation impacts the quality of mathematics education students receive. Many of the teachers in this study indicated that the planning and organisation of mathematics lessons is different to other subjects, in terms of how much time, energy and thorough preparation they feel is required in mathematics education. In preparing mathematics lessons teachers consider a range of factors, including how to make the mathematics engaging and relevant to students, how to connect sometimes abstract ideas to real life, and how to cater to the needs of all their students:

> I actually have, um a separate daily work pad, a support daily work pad … and maths is a big one … it makes me more organised, especially with maths, because you can't just wing it. (Gemma)
>
> Wherever we can see something that fits in, we try to, we try to tie it in. So, we actually, yeah, we rejig our program so that they coincide with one another, with our units of enquiry… and that makes it quite meaningful and fun for the kids, and they can see the point of why we, why we learn these things. (Amy)
>
> Finding resources that engage the students as learners, but that also have some real-world relevance, which is where investigations in maths are great. (Michael)
>
> You've got the curriculum, but then how do you make it, because every year there's a different group of kids, it's a slightly different context, and if you move from school to school maths is taught differently, but it is how do you, I suppose, relate to the students you've got at that particular time to make it interesting?… for me it's good if I've got a really set plan… making sure I've got the correct structures set up within the classroom, that's probably the biggest thing I do, um, and not rushing things. (Adam)
>
> How I go about maths is very different to how I go about literacy. (Sam)
>
> Mathematics is probably the subject that I probably think about the most, in terms of sequencing, in terms of groupings, in terms of how I'm going to do it … it's the subject I do spend the most time on. The most time I think about whether I'm doing a good job, whether the lesson that I planned is interesting, and explicit enough as well, for them. (Paul)
>
> I try to be very thoughtful in what we do and how we do it, compared with some of the other areas where I feel more comfortable and I don't need to spend the time to put together my knowledge. (Stacey)

> Something that I've discovered with my maths teaching is I need to do things from lots of different ways, because kids, it's very evident that kids learn differently in maths and just the way they make connections, and all of that type of stuff, and those real-life examples. (Zoe)
>
> I think that maths is unique in where it has such a high barrier to entry for a lot of, a lot of kids, and so that makes most sense for me to do as much, um, preparatory work as, as possible. (James)

Despite training and experience, sometimes teachers can run out of ideas to address student needs:

> There'll be just be occasions when they just, just don't want to do it anymore, and, and then, they'll just tell you they don't understand it, and it's very frustrating because you know, you have, you have changed, chopped and changed your methods about how to teach this and it's just not working anymore, and yeah, they feel a sense of helplessness and so do I. (Paul)
>
> When children struggle with it, it is hard because sometimes I feel like there's only so many ways you can explain something. So, if you've explained it by putting it together and by pulling it apart and doing this and doing that and then you, kind of, flatline about 'well, what else can I say' like this is what I've got, I've told you everything I know, I've changed what we've used, I've change the counters, I found a video, and you do kind of find yourself being like 'okay, we'll just wait'. (Stacey)
>
> Fractions are an area that, you know, sometimes, they just don't get, and it doesn't matter what you do, whether you bring in chocolate cake and cut it up, whether you have, you know, the fraction wooden cake, or fraction charts, or whatever. Sometimes they just will not get fractions. (Michael)

The combination of the crowded curriculum, of schools being so busy, and of the wide range of student abilities in mathematics with an expectation for all to succeed but no single approach that is effective in enabling all students to meet curriculum achievement outcomes, impacts a teacher's experience of mathematics education. The participants in this study felt time-poor and experienced frustration due to the challenge of meeting student needs under these conditions:

> That's the frustration that I have about mathematics as well, like, you know we have all these demands about mathematics, but yet we only have a finite amount of time to teach it, and then, you know, I will teach one concept, for like two weeks, and then I leave it and then, because, not because I want to

> necessarily, but because I have to move on because there is a gigantic curriculum that I cannot possibly cover, because there's all these interruptions, and it's a really busy school anyway, you know, and I only get to see my maths groups for four periods each week, and if I don't move along, um, like some sort of maniac, and sometimes I do feel like that I'm just racing through it. Teach, teach, teach, revise, revise, revise, practice, practice, practice, 'alright guys, we're moving onto something else'… you talk about it for a week or two, you leave it, and there's no chance to practice it again unfortunately … I'd like less inside the curriculum … my grievance is, of course, is that there's just too much, too many things to pack into the whole year. (Paul)

> I always feel like when you pass them on to the next grade, you know, if I just had a bit more time … because then it causes more problems as you come up, you know the gaps get bigger and bigger and bigger. (Gemma)

> We're not providing enough time and exposure to experiences to allow those open-ended things, it's the, it's the, and the kids driving the interest and curiosity, we don't have time to allow that, and I think that's a really dangerous thing because, as I said before, maths and science being so closely connected, because we're not allowing them to just explore, because we don't have the time to. (Zoe)

4.3 SUMMARY

The group of teachers who participated in this study all displayed a high level of enthusiasm for teaching mathematics to the best of their ability and perceived themselves as influential for student success in mathematics, a high-stakes subject. While these teachers described their enthusiasm as important, their experiences also indicated that enthusiasm alone is not enough. The teachers described the challenges encountered in learning mathematics and the complexities in learning how to teach mathematics.

School, curriculum, testing and reporting requirements were found to impact teachers' pedagogical choices. In general, the teachers felt time-poor. An integrated approach was seen as beneficial, as a time-efficient way to get through all of the curriculum and because it helps students to see the relevance of mathematics; yet many of the teachers perceived obstacles to this approach and experienced mathematics as, generally, an isolated subject.

In relation to the importance placed on mathematics education, the teachers placed a large focus on meeting individual student needs and addressing student affective factors such as anxiety, lack of confidence and fixed mindsets. The teachers indicated that mathematics teaching requires thorough planning due to the wide range of student abilities as well as the nature of the subject of mathematics. In their experience, it is not realistic to expect all students to reach a set level of attainment, revealing that there is a disconnect between the way success in mathematics is reported and their aims in mathematics education.

This chapter presented the findings of the research through a comprehensive narrative. The following chapter contains a full discussion of these findings, with reference to the professional and research literature.

Chapter 5: Discussion

Research has shown that teaching practices have a significant impact on student learning and achievement (Finlayson, 2014; Heyd-Metzuyanim, 2013; Kleinhenz & Ingvarson, 2004), and low mathematical achievement can negatively affect overall learning and opportunities in life (Holmes & Dowker, 2013; Mulligan, 2011; Sherman et al., 2009). Despite targets for all children to succeed, TIMSS assessment results in 2015 revealed approximately one third of Year 4 students in Western Australia are performing at or below the low international benchmark – the designated 'proficient' level in mathematics (Thomson et al., 2017).

To address a gap in the existing literature, and to generate new understandings of this situation, the overall aim of this research was to explore the lived experience of primary school mathematics teachers in Western Australia. The main research question therefore asked how primary school teachers perceive and experience mathematics education. To provide insight into relevant contextual factors, the research also considered how primary school teachers perceive their experiences of mathematics education to have changed during their career.

Data were collected through semi-structured in-depth interviews, and analysed in line with a transcendental phenomenological approach. Through a phenomenological approach the subject and object can be distinguished yet united, the interaction between them creating the images or essence of what it is like to be engaged in the experience (Crotty, 1998), mathematics education in this case. The focus is therefore not solely on the participants and how they construct their experience, nor on their working environment that shapes their reality, but on the relationship between the two.

The process of data analysis was demonstrated in Chapter Three, and findings were presented in Chapter Four. In Chapter Five, these findings form the basis of three themes for discussion:

1. The complex nature of learning mathematics and how to teach it, in comparison to other primary school subjects.

2. The impacts of external pressures experienced by teachers involved in mathematics education.

3. The wide range of abilities in, and student dispositions towards, mathematics.

These themes are discussed as they pertain to each of the research questions in Chapter Six.

Prior to discussing each of these themes it is important to reiterate this research is based within the context of a phenomenological study. As such, it does not seek to measure, establish a cause and effect relationship or generate a theory regarding mathematics education. Rather, it seeks to analyse and describe the experience of teaching mathematics in primary schools (Mohanty, 1989).

Within this chapter the constructs 'pedagogical content knowledge' and 'professional learning' will be presented again using the acronyms PCK and PL respectively, and the 'National Assessment Program – Literacy and Numeracy' will be referred to as NAPLAN.

5.1 THE COMPLEX NATURE OF LEARNING MATHEMATICS AND HOW TO TEACH IT

The overall perception and experience of learning mathematics and how to teach it, described by the teachers in this study, is that it is a unique and complex subject, in comparison to other subjects at primary school level, and hard work for both students and teachers.

The teachers described several challenges in learning mathematics, such as "it's almost like it's a foreign language to a lot of students" (Claire). To overcome these challenges, the group of teachers in this study described how they scaffold learning in mathematics by: teaching sequentially; structuring learning to connect concepts to real life, or to connect concrete and visual representations to abstract concepts and symbolic notation; and purposefully exploring the language of mathematics.

This scaffolding of learning in mathematics was perceived by the teachers as crucial for student engagement and understanding, which resonates with Sfard's

(2008) perception that in order to learn mathematics students require the opportunity to become involved in a “positive cycle of participation” (p. 161). Furthermore, the understanding of how students learn mathematics shown by these teachers, along with the teaching approaches they described, aligns with Piaget’s theories of knowledge being actively constructed through assimilation and accommodation. Also, in line with Vygotsky’s sociocultural theory and working within a student’s zone of proximal development, the teachers spoke about: discovering gaps in student knowledge; finding out what they can do and building from there; and sharing understandings and strategies through class discussions.

These teaching approaches correspond to recommended teaching strategies. In particular, the teachers described the difficulties students can have in ‘de-coding’ teacher talk in mathematics, also described by Sfard (2008), and as such they recognised the importance of providing opportunities for whole class discussions and peer learning. Many of the teachers, however, indicated that they need more time to allow sufficient opportunities for students to practice and consolidate learning, especially the teachers of Year Two and above. These teachers attributed the demands of a crowded curriculum to the feeling of being time-poor.

Some teachers indicated that they share Sfard’s (2008) perception that meaningfulness and “stable associations” (p. 196) can be gained from repeated use, and the findings indicate that teachers can often feel a conflict between the need to move on in order to get through all of the content, and the desire to spend longer on the current topic to consolidate learning. To exemplify, participants expressed “there’s nothing worse than having to move on from a concept knowing that you haven’t quite got all the kids there” (Amy); and “if I just had a bit more time … because then it causes more problems as you come up, you know the gaps get bigger and bigger and bigger” (Gemma).

A teacher’s decisions about what to teach when, how to teach it, and how much time to spend on each topic, can each be influenced by the teacher’s PCK. In exploring the journey of learning how to teach mathematics, the findings of this study resonate with the findings of Beswick and Goos (2012), revealing that the vast majority of teachers feel unprepared to teach mathematics when they begin their teaching career.

In addition to the influence of training, learning through experience, and internal or external PL opportunities, this study revealed that teachers also draw on their own past experiences as students of mathematics. The findings reveal that whether experiences were positive or not, the teachers in this study were all keen to transfer positive feelings about mathematics to their students. The only negative student experience that the findings indicate can impact the teaching of mathematics negatively appears to be anxiety. As a student, Stacey did not enjoy mathematics and a feeling of anxiety can persist in some areas of her mathematics teaching. Stacey's descriptions of the frustrations she, and her students, can experience concur with existing research that suggests that parents and teachers who experience mathematics anxiety themselves may pass this on to the children in their care (Finlayson, 2014).

Stemming from the literature, the gap in research appears to be in exploring how teacher knowledge changes over time and how this affects a teacher's experience of mathematics education. All the participants felt that they had improved in their ability to teach mathematics during their careers, and this study found that teachers experience the most growth through teaching in the classroom, combined with reflective practice, with the effects of this further enhanced through changes in year level or school. The Australian Institute of Teaching and School Leadership (AITSL) provides a framework of "Professional Standards for Teachers" (Australian Institute for Teaching and School Leadership, 2018), available to help with self-reflection. These standards were only mentioned by one of the teachers in this study when asked how they identify their PL needs, which could have been due to the open-ended nature of the interview questions, or may suggest AITSL documents are not routinely referred to. Contrastingly, this study indicates that the context within which teachers work has a significant influence on both their choices and their experience.

The teaching approaches chosen by teachers appear to reflect the expectations of their immediate teaching environment, even when these do not align with the teacher's beliefs. For example, one participant explained:

> In my last school it was explicit education was the big focus and that took away from hands-on at times, um, it was a Pre-Primary class and I had a lot of PowerPoint presentations to introduce topics … and that took away from my own pedagogy of maths should be hands-on in the early years. (Stacey)

The scenario of teachers adapting their practice according to the expectations of each school, despite conflicts with their own beliefs, is somewhat in contrast to reasons given for the slow uptake of reform, such as: teachers are unlikely to change their practice if new recommendations do not conform to their beliefs (Beswick, 2005). A teacher's willingness to comply to the expectations of different schools, even if this does not align with his or her beliefs, could also help to explain why, within educational research, what teachers report to believe in surveys does not always match what is observed in their practice. The findings indicate that different schools encourage different pedagogical approaches to mathematics education, offering support for research that asserts there is a "huge variation and no common agreement as to what constitutes *quality instruction* in mathematics" (Mason, 2016, p. 222).

The findings also indicate that a teacher's experience does not only vary from school to school with regard to teaching approaches, but also with regard to the level of support each school provides. The teachers in this study highly valued the internal support provided by their schools, but many of the participants who had worked at other schools described how support can vary significantly from one school to another:

> From nothing to everything, like that. (Sam)
>
> I just wonder how much support graduates get when they actually land in schools. I mean, we support our graduates hugely here. But I think back to when I went to Meekatharra for my first two years, I had no idea what I was doing, and I didn't get any support from anyone up there. (Claire)

This study found that learning through external PL opportunities also varied, as did the experience of PL opportunities themselves. Existing literature has raised concerns over top-down or 'politically driven' programs that seek to change what teachers do, and studies have indicated that this type of PL opportunity can be ineffective and meet resistance (Beswick, 2014; Muir et al., 2010). The findings of this study indicate that teachers are open to new ideas, but may not always see how these ideas can be successfully implemented:

> Sometimes it's really good and you can implement it straight away. Sometimes there's professional learning where I find that it will take a bit of time, for me, first to understand, and to see whether I can incorporate it into

> my practice… there's so much stuff available, but actually, sometimes it works, sometimes it just really doesn't. (Paul)

One participant also indicated that being time-poor contributed to her choosing not to engage in many external PL opportunities:

> I haven't accessed a lot of outside PD because, it's also, you're taking a bit of time off class, and that is quite stressful when there's not a lot of time anyway. (Zoe)

Furthermore, this study did not reveal evidence of continuous PL occurring, thereby supporting assertions by Lerman (2013) that teachers more often engage in short-term PL programs or research projects. Interestingly, none of the participants in this study suggested that they had learnt specifically about teacher-noticing, or effective feedback, and they were also not accessing education research, unless in a leadership role. The cost of accessing education research, and language used within it, were not mentioned as reasons for a lack of engagement with research literature - reasons suggested by MacLellan (2016) - but it should be noted that the teachers in this study were not asked directly about their reasons for not being a participant in research, or a consumer of research, in mathematics education. It could be inferred from the findings of this study that, as teachers are time-poor, there are few windows of opportunity to explore what is available; or it could be the case that when teachers become increasingly competent in their role they reach a plateau of growth, as suggested by Evans (1996), and their motivation for seeking opportunities to learn diminishes. Without exploring this issue more directly, this remains speculation, but does point to questions that remain to be answered regarding the reasons for, and possible solutions to, the persistent gaps that exist between research and practice in teaching.

5.2 THE IMPACTS OF EXTERNAL PRESSURES EXPERIENCED BY TEACHERS INVOLVED IN MATHEMATICS EDUCATION

The findings reveal that there are aspects of the context within which teachers work that are conducive to teachers experiencing pressure and internal conflict. For example, the importance placed on mathematics and associated achievement targets, along with the means by which achievement is assessed and monitored, can create pressure.

The teachers perceived mathematics to be an important subject and considered it necessary to address levels of student attainment in this subject. This view of mathematics is widely held because numeracy capabilities are considered to be essential in order for people to function effectively in society (Australian Curriculum, Assessment and Reporting Authority, n.d.b) . As such, the teachers experienced the need to: scaffold learning in mathematics; address the wide range of student abilities and affective factors; and meet curriculum and school expectations. Some teachers therefore felt that mathematics is the subject they spend the most time on, in terms of planning and reflecting. These findings support assertions that "mathematics tends to be regarded as one of the most difficult subjects, especially in primary education" (Alegre, Moliner, Maroto, & Lorenzo-Valentin, 2019, p. 768).

In line with the importance of mathematics education, mathematics is one of only two subjects undergoing national testing each year in primary schools, with the findings concurring with previous research that NAPLAN testing impacts a primary school teacher's experience of mathematics education. To elaborate, NAPLAN testing can be experienced as stressful, unreliable, and in conflict with how teachers judge success in mathematics.

Many of the participants in this study perceived NAPLAN testing as stressful for some students and also experienced pressure themselves. These findings align with previous research by Polesel, Rice and Dulfer (2014), and by Cranley (2018). In particular, evidence that teachers of students in the year before NAPLAN testing are likely to experience the most pressure, as they perceive the results to be a reflection of their teaching, was found by Cranley (2018) and confirmed by the participants in this study.

Some participants described NAPLAN as unnecessary pressure, possibly because the measure of success did not align with their views of success, or because they perceived that NAPLAN results are not reliable. The perception that NAPLAN results are unreliable was also reported by Cranley (2018). Some teachers described discrepancies between NAPLAN results and their own assessments of individual students, many wondering if this was due to the nature of the test being multiple choice, with students either being lucky on the day or not performing on the day for some reason.

It is interesting to note that while the teachers in this study felt that the discrepancies were due to the unreliable nature of one multiple choice test on one day, in Cranley's study the discrepancies noticed by parents between school reports and NAPLAN results "gave the parents cause to question the school's ability to accurately assess their children's mathematical achievement" (Cranley, 2018, p. 105). Both studies reveal that teachers perceive the test as 'one size fits all' in nature and not able to show what each student is capable of.

Success, according to the teachers in this study, includes: reasoning ability; acquiring skills for life; progress or growth; students developing a positive disposition towards mathematics; aha moments; and students being prepared for later learning. They did not perceive success as meeting a set level of attainment, as measured by NAPLAN. Despite a lack of agreement with regard to how best to measure success, the findings show that teachers feel under pressure to support their students in obtaining the best results possible, and as such may alter their teaching in preparation for NAPLAN testing. These findings also concur with research conducted by Cranley (2018) and Polesel et al. (2014), who found that teachers can both feel under pressure to spend time preparing students for NAPLAN, and feel conflicted about NAPLAN therefore changing the way they teach, with concern for the impact on students.

Furthermore, the requirement to provide grades was also described by some participants as counter-productive to their efforts in addressing affective factors in mathematics, as they feel that this system does not allow for students developing differently or depict the progress the student has made - it only shows where the student sits against expectations for their year level. Some participants therefore felt that they are labelling students by providing a grade and expressed concern over the consequences of this. These perceptions align with concerns raised by Riddick (2012) over the danger of labels becoming a self-fulfilling prophecy.

The findings reveal that internal conflict can also exist for teachers where other requirements of their teaching context do not match what they believe is best for their students. Sources of this conflict included: the curriculum; resources provided, such as programs and textbooks, chosen for them by their school; and set timetables.

Although the curriculum has positive aspects, found useful by the teachers for the hypothetical learning trajectories it provides, the focus on all students reaching a set level of attainment, with related tests and grades, was not experienced as helpful by many of the teachers in this study, especially as they perceived these requirements to work against their efforts to address affective factors. These findings are in accordance with assertions that a ‘one size fits all’ approach is unresponsive to individual needs (Yackel et al., 2011).

Internal conflict also appears to be created as teachers feel they need to cover all of the curriculum in the time available, with many describing the curriculum as crowded, resulting in them feeling time-poor. The crowded curriculum has also been acknowledged in previous research by Hurst (2015a). The lack of time was indicated by the participants as being: restrictive on teaching choices; contributory to the wonder of mathematics being lost; and reducing opportunities for students to achieve mastery, or different levels of learning, as they feel they have to rush through the content and move on to new topics before they would like to. These findings concur with Brown’s (2016) assertion that “the wonder of mathematics is often lost in schools” (p. 76) due to the focus on accountability and testing regimes. The impact of teachers feeling time-poor is that it appears to interfere negatively with student learning of mathematics by fuelling a situation where students may either develop gaps in learning, or end their learning at a ‘surface level’, the latter a commonly occurring situation according to Hattie (2017).

The experience of internal conflict due to resources provided by a school can be exemplified by the unspoken expectation, perceived by some of the teachers in this study, that if a textbook is purchased then it should be completed. These teachers perceived that, although textbooks may provide consistency and guidance, they are not always perfectly suited to their needs. The impact of conflict arose due to the combination of a perceived need to complete the textbook in conjunction with feeling time-poor, as the teachers using textbooks felt that they didn’t have the time to both complete the textbook and implement their own preferred approaches.

Resources also include human resources. The teachers who had taught at different schools found the level of support to vary significantly. One participant talked about different demands in terms of student behaviour management, and the pressures experienced and impact on learning when they felt they lacked adequate support.

The school timetable is an element of the teaching context which also appeared to restrict the teachers from implementing teaching approaches they thought would be beneficial. In common with each other - and in agreement with research and recommendations - the teachers in this study perceived there to be great benefits in integrating mathematics with other subjects, and many participants believed that integrating mathematics across the curriculum would be a good strategy to get through the content. However, most of the participants described barriers to an integrated approach, including having mathematics timetabled for a certain period with some students leaving the classroom for support or extension, or having students streamed for mathematics, thereby isolating mathematics. The participants described further barriers to integration - such as the time it takes to plan that way, and having to teach specific rules and skills explicitly – but it is possible that these are only experienced as barriers to integration due to the feeling of being time-poor.

Finally, requirements of the teaching context appear to cause internal conflict when schools encourage pedagogical approaches that teachers do not agree with, but feel pressured to comply with.

5.3 THE WIDE RANGE OF ABILITIES IN, AND STUDENT DISPOSITIONS TOWARDS, MATHEMATICS

The findings show that the teachers' experiences of students in mathematics include a wide variety in student responses to mathematics, in terms of ability, in-the-moment responses to teaching, and affective factors.

The teachers indicated that meeting individual needs within a class, where there is typically a wide range of student abilities, is challenging. There can be an extremely wide range of ability within one class:

> Right now I've got one student who is working at probably at Year 10 level, and then I've got some kids who can't count on from 5 to 10, so you've sort of got that big range. (Adam)

It has been asserted that interventions in mathematics often involve students leaving the classroom to work with a support teacher (Gersten et al., 2009). The findings of this study support this assertion, as the teachers at both schools in this study described students leaving the classroom to access either support or extension. One participant expressed concerns over the negative effects this approach to intervention can have, and her views resonate with previous research suggesting that leaving the classroom can be a stigmatising experience (McLeskey & Waldron, 2007, p. 165). Leaving the classroom also means that these students miss the content being covered at that time with the rest of their class, and if they are spending time with support teachers revisiting the basics then they are not receiving the same access to high level content as their peers – it has been asserted that this is not a situation which is conducive to equitable achievement (Boaler & Dweck, 2015).

In addition to some students leaving the classroom for support or extension, the teachers also described working with small groups and individuals based on ability within the classroom, an approach in line with some recommendations seeking success for all, but not in line with the recommendations of Anthony et al. (2019), whose focus is on equity, raising the question "is differentiation the answer?" (p. 117). The teachers' experience of challenge in striving to meet individual needs in mathematics, and of occasionally feeling helpless or running out of ideas, corresponds to previous research findings that mathematics learning difficulties are challenging to diagnose (Kucian & von Aster, 2015), interventions are complex (Gersten et al., 2009), and no single teaching approach will be effectual in all cases (Gifford & Rockliffe, 2012; Sherman et al., 2009).

It is also possible that the wide range in abilities is related to the experience of students responding in a variety of ways to the same teaching and discussions, a scenario depicted by Goldin (2011) and confirmed by the participants in this study:

> The challenges with maths is the ability of kids to be able to quickly grasp, need repetitive teaching, or not grasp a concept, from one given lesson, is so diverse that that blows my mind every single time I do it, so that's a challenge for me. (Gemma)

As no single approach appears to be effective for all students, this can make planning and implementing mathematics lessons challenging and complex. The findings indicate that the planning of mathematics lessons appears to require careful thought and is a time-consuming process. Many of the participants experienced peer learning as beneficial and described how they create opportunities for collaborative learning to occur, but as the literature suggests, even this approach can be ineffective for some children (D. Evans, 2007).

The findings reveal that, due to the complex nature of learning and teaching mathematics, sometimes teachers can run out of ideas to address student needs. These findings support assertions that knowledge of appropriate solutions, rather than a negative attitude, can inhibit a teacher's ability to cater for the diverse range of needs in his or her classroom (Vaz et al., 2015). While the findings show that teachers can experience concern for students in mathematics education when students do not achieve expected outcomes, from Year Two and above it is also the case that they do not believe it is realistic for all students to achieve the set levels of attainment dictated by the 'one size fits all' curriculum. As such, the findings indicate that teachers may prefer to focus on individual growth, or perceive a need to wait in some instances. Existing literature indicates that student achievement can be related to teacher efficacy beliefs (Riggs & Enochs, 1990) and that effective teachers hold "high expectations of initially low-attaining students" (Geeves, 2014, p. 18), suggesting that it could be the case that the beliefs held by the teachers in this study may not be helpful in addressing the achievement gap. Alternatively, it could be the case that the teachers held realistic beliefs - that targets set, and associated measurement and reporting methods, are setting some students up for failure - given literature that indicates a strictly adhered to 'one size fits all' curriculum is unresponsive to individual needs (Yackel et al., 2011) and that 'one size fits all' testing does not provide students with the opportunity to demonstrate what they are capable of (Cranley, 2018).

Just as teacher beliefs impact teaching and learning, so does the diversity of student beliefs and attitudes. The findings of this study indicate that teachers plan and act with an awareness of their students' affective domain, talking predominantly about student anxiety, engaging students, and making the mathematics learning environment a safe place for students. Despite also trying to make mathematics fun as much as possible, and being sensitive to student feelings about mathematics, these teachers indicated that when students have a fixed and negative mindset, this can be difficult to change:

> They'll just be paralysed by it, and, not by anything more, but just the idea that we are doing maths, will just paralyse them. (Paul)

The experiences teachers have, encountering students who appear to be either paralysed by mathematics anxiety, or to have given up and are unwilling to engage in mathematics learning, resonates with previous research. For example, these experiences resonate with research that asserts: mathematics can elicit strong emotions (Batchelor et al., 2019); in responding to failure, a student may engage in a pattern of avoidance (Crozier, 1997, p. 136); and the emotions associated with previous failures in mathematics can inhibit a student's ability to engage in mathematical work, even when the task set is appropriate for them (Kolacinski, 2003). Student self-efficacy beliefs have been identified as the "strongest predictor" of attainment in mathematics (Council of Australian Governments, 2008, p. 50) and, accordingly, the participants all described strategies they employ in their mathematics teaching to address student affective factors.

Many teachers in this study observed that when students have negative experiences in mathematics this can produce a pervasive mindset, impacting how students view themselves as learners generally, as well as socially. These perceptions are in accordance with Boaler's (2000) assertion that "students do not just learn mathematics in school classrooms, they learn to *be*" (p. 188). The participants' descriptions of encountering students who exhibit learned helplessness, not only in mathematics but also spreading into other areas of the student's life, aligns with research that suggests that the low self-efficacy associated with learned helplessness can lead students to believing they will never succeed at school (S. Yates, 2009, p. 84).

To prevent or overcome these difficulties, all the teachers described hands-on activities and fun as important aspects of mathematics learning. Unfortunately, due to feeling time-poor, many of the participants felt conflicted, not always able to teach according to the methods they thought would be best for their students. Another strategy employed by the teachers to ameliorate affective factors was the use of praise and verbal encouragement.

This study did not focus on praise in sufficient detail to establish whether each teacher's use of praise was in line with current recommendations or whether the teachers were aware that, according to research, praise can be confusing to students or deter them from reviewing their work (Hattie, 2012). Further research into how encouragement and support is given in mathematics could be beneficial, in particular if combined with consideration of whether students are being protected from 'negative' experiences and emotions that could actually benefit them, rather than being supported to overcome challenges (Goldin et al., 2011).

5.4 SUMMARY

This chapter discussed the research findings, with reference to the professional and research literature. The literature thoroughly outlines the complexities of learning mathematics, and the findings reveal how this impacts teachers. The participants found that the nature of mathematics, in comparison to other primary school subjects, requires them to develop specific PCK and to spend time considering a wide range of potential student responses in their careful planning of mathematics lessons.

The complex nature of mathematics is reflected in both the literature and the findings, as are criticisms of a 'one size fits all' approach to this subject. The findings of this study reveal that teachers experience significant differences between schools in terms of their expectations and requirements, and struggle to support their students in achieving set levels of attainment. While each school's expectations and resources impact teaching options and choices, every school follows the curriculum and implements NAPLAN testing.

Previous literature has described the curriculum as crowded, and the findings of this study provide further insight into the effects of this. Teachers may be knowledgeable about how children learn mathematics and employ recommended teaching strategies, but being time-poor can restrict their options and prevent them from adequately meeting individual needs, as they experience having to move on from a topic before everyone is ready. These pressures also impact teachers' abilities to cultivate curiosity, and to consolidate and extend learning.

The following chapter: provides a brief summary of this research project; further explores the implications of the findings and discussion by addressing the research questions; and identifies implications and recommendations for the teaching profession and future research.

Chapter 6: Conclusions

The purpose of this research study was to analyse and describe the experience of mathematics education in primary schools from the teacher's perspective, with potential research impact from the exchange of knowledge between teachers and researcher, and back to the education community. This study addressed a gap in education research, giving a voice for primary school teachers, providing insight into their experience of mathematics education from their perspective.

The research gained insights into the relationship between the demands of the profession and the context within which teachers work, therefore engaging with the concerns of teachers, school leaders, those involved in curriculum development and professional learning, and policymakers. Data from semi-structured in-depth interviews were collected and analysed through a transcendental phenomenological approach. Findings were presented in Chapter Four and discussed in Chapter Five.

Through this approach the research aimed to generate new understandings, by gaining insights into primary school mathematics teachers' lived experiences. It is hoped that this may open dialogue for teaching practices, which could ultimately be of benefit for student outcomes.

Limitations of the research include: the small number of participants that took part in the study; the participants only represent one sector of education; the requirement for voluntary participation; the semi-structured nature of the interviews; and the need for interpretation of data. Although only 12 teachers were interviewed, a phenomenological study requires an in-depth exploration of experience and it is considered that a large number of participants is not required. As such, teachers were recruited for this study to the point at which new information did nothing to further the understanding of the phenomenon. Voluntary participation means that experiences of teachers willing to share their experiences was captured. It is possible that those teachers who chose not to participate have a different experience, and it is recognised that experiences may vary for teachers from other sectors. Further, the semi-structured nature of the interview protocol may have influenced the themes that emerged from the data. Although use of the interview questions alone may have led to different themes, use of the prompts where necessary guaranteed a greater depth of information was gathered. Finally, there are natural limitations to interpretation. It would be difficult to reproduce the study and get exactly the same results, as the aim was to establish the experiences and perceptions of individuals, which are inherently unique. A mitigating feature of the research design is that common themes were used to construct the final narrative and, to address concerns regarding interpretation, these themes were checked by other researchers as well as the participants themselves. As expected with phenomenological studies, it is not possible to generalise findings, but the findings can nevertheless be informative to those in education, in similar and different situations.

In exploring the phenomenon of mathematics education, from the perspective of primary school teachers, the main research question posed was:

1. How do primary school teachers perceive and experience mathematics education?

To ensure the research provided insight into relevant contextual factors, the research also considered:

2. How do primary school teachers perceive their experiences of mathematics education to have changed during their career?

This chapter addresses these research questions, with conclusions based on the findings and discussion presented in Chapters Four and Five. As a result of these conclusions, implications and recommendations are identified.

6.1 HOW DO PRIMARY SCHOOL TEACHERS PERCEIVE AND EXPERIENCE MATHEMATICS EDUCATION?

The findings indicate that teaching mathematics is a complex and challenging endeavour, in comparison to other primary school subjects. As such, some teachers felt that mathematics is the subject they spend the most time thinking about, both in terms of reflecting on past lessons and planning future lessons. Key contributory factors appear to be the importance placed on mathematics education combined with the wide range of student abilities in and dispositions towards mathematics.

While the aims of mathematics education, described in the Australian curriculum, include a focus on developing “understanding, fluency, reasoning and problem-solving skills" (Australian Curriculum, Assessment and Reporting Authority, n.d.b), student achievement is monitored through NAPLAN results. It could therefore be suggested that success in mathematics - in terms of national targets - is reaching a level of proficiency or above. The findings of this study show that the teachers' definitions of success somewhat correspond to the aims of the curriculum, but they did not perceive success as meeting a set level of attainment, as measured by NAPLAN or communicated through school reports.

The teachers' perceptions of success in mathematics were therefore not in line with how student achievement is measured and reported, or how schools are judged. Success, according to the teachers in this study, includes: reasoning ability; acquiring skills for life; progress or growth; students developing a positive disposition towards mathematics; aha moments; and students being prepared for later learning. The teachers indicated they thought that it is possible for all students to enjoy mathematics and to grow in their understanding and abilities in this subject, but found that even this can be difficult to achieve in time-poor circumstances. They did not perceive it to be realistic for all students to achieve set levels of attainment, suggesting that a 'one size fits all' approach, in terms of curriculum and testing, is potentially setting some students up for failure.

There is therefore agreement between existing literature and the participants' perspectives, in that a 'one size fits all' curriculum is unresponsive to individual needs, and that 'one size fits all' tests are not able to show what each student is capable of. In agreement with existing research into the impact of NAPLAN testing, the participants in this study perceived the nature of this type of assessment, being a multiple-choice test on one day, to be unreliable, putting unnecessary pressure on students and teachers.

In terms of meeting each student's needs, the teachers described mathematics eliciting strong emotions in some students, and believed that a student's mindset is important for learning. As such, the teachers described strategies they employ to engage students, to make their classroom a safe place to explore mathematics and learn from mistakes, to set work at an appropriate level, and to offer support to individuals and small groups as required. It was not clear whether, in doing this, teachers are aiming to protect students from all 'negative' emotions in mathematics, such as frustration.

Students in both schools also left the classroom for either support or extension in mathematics. While interventions in mathematics commonly involve leaving the classroom to work with a support teacher, this can be a stigmatising experience, and a fragmented schedule can make learning and teaching more difficult. As there is no common agreement and conflicting advice in the literature, how best to differentiate and achieve equity in the mathematics classroom is not clear. This situation is somewhat reflected in the experiences of teachers, with participants in this study describing moments when they run out of ideas, where student responses and difficulties vary and solutions are not always obvious, and when they can feel helpless. At times like these, some participants perceived the need to 'just wait'.

Nevertheless, teachers perceive that they are held accountable for student attainment and, especially in the years prior to NAPLAN testing, they are likely to feel under pressure. Although cognisant of effective teaching strategies to meet the academic and emotional needs of their students, the findings reveal that teachers can often feel conflicted, having to choose between what they think would be best for student learning and wellbeing or meeting external requirements. Examples of perceived external requirements included: covering all of the curriculum in the time available; preparing students for NAPLAN; completing set pieces for work for assessment to show consistency in a multi-streamed school; or completing a textbook that has been provided, but may not be completely suitable.

The feeling of being time-poor was significant, and attributed mostly to the 'crowded' curriculum. The most significant implication, in terms of student learning outcomes, is that teachers often feel they have to move on from a topic before they would like to, fuelling various concerns. To elaborate, the teachers expressed concerns over students developing gaps in their learning, which are only likely to get bigger as the student progresses through the school. Concerns regarding student engagement and student self-efficacy beliefs decreasing were also raised. Teachers perceived associated negative impacts on future mathematics learning, as well as students' overall perceptions of themselves as learners and their ability to succeed at school. In addition, the crowded curriculum was found to impact the potential for students to receive adequate exposure to enrichment activities. Enrichment activities in this context can be described as: mathematics games, which help consolidate learning and foster enjoyment of mathematics; investigations and problem solving activities, which can promote deep and transfer learning, stimulate curiosity, put mathematics into a real-life context to demonstrate the relevance of skills learnt, and may provide opportunities to develop perseverance; and integration of mathematics with other subject areas.

Both the mathematics curriculum and the overall curriculum was perceived as crowded by the teachers in this study. One quote from an interview which resonates with respect for the work that has been put into creating comprehensive curriculum documents, but also speaks to the desperation of those trying to fulfil curriculum requirements, summarises the context within which mathematics is currently taught:

> It's (the curriculum) huge. There's so much, and there's not enough time for that in relation to everything you have to do in HASS and everything you have to do in English, and then now with technology, and then economics and business. So, just with everything you have to do in all of the curriculum, it just, you know, and there's only so much you can spend on each subject, … it reminds me of being in high school where, um, each teacher thought that their subject was the most important one that was out there, and so you should spend your entire life on that, it seems like a very similar thing that's happened with the framework, with the curriculum sorry, is that each committee that's got together and written it, knows, are experts at what they're doing, you can read that in there, but they've forgotten that there's all those other things that have to be done, and then we're putting them all onto teeny-weeny children, who, on babies, who are, you know, just trying to grow. (Zoe)

The ability to integrate mathematics with other subjects was valued by those who could do this, as a time-efficient way to get through content. However, some teachers indicated that there was not time to both teach mathematics explicitly as well as through an integrated approach, and additional barriers to integration were also identified. For example, if students are streamed for mathematics their teachers could not integrate mathematics across the curriculum because they did not see many of their mathematics students in other lessons, or when mathematics is timetabled for a certain period - and some students go out for extension or support during that time - then it was perceived as isolating mathematics. Although many of the teachers felt that integrating mathematics throughout the curriculum would be beneficial, most participants experienced the majority of mathematics education as isolated rather than integrated.

Despite the aforementioned challenges and concerns experienced by the participants, the group of teachers who participated in this study all displayed a high level of enthusiasm for teaching mathematics to the best of their ability. In particular, the participants spoke about their own experiences as students learning mathematics, and it became apparent that they have been influenced by, and draw upon, their past experiences as learners. In common with each other, regardless of positive or negative experiences as learners of mathematics, the teachers in this study appeared motivated in their teaching of mathematics to transfer positive feelings about mathematics to their students.

Many of the participants perceived that mathematics could be a ‘fun’ learning area, and associated the possibility of students experiencing fun and enjoyment with mathematics, especially when hands-on learning experiences and games are involved. While all the participants in this study displayed a positive disposition towards teaching mathematics, some indicated that their feelings about mathematics had changed during their career. Findings regarding teachers’ perceptions of how their experience of mathematics education has changed during their career will be expanded upon in answer to research question two.

6.1.1 Implications and Recommendations

These findings have implications for policymakers, school leaders, teachers, students and education researchers. It is recommended that all stakeholders work together to establish more reliable and equitable methods of measuring and reporting student attainment in mathematics. It is suggested that solutions focus on reducing the negative effects of labelling, as well as establishing what is realistic and valued in terms of defining success. For example, more emphasis could be put on reporting progress and developing personal skills, such as resilience, perseverance, creativity and analytical thought.

Given teachers are already time-poor, it is especially important that new methods of measuring and reporting success in mathematics are both useful and manageable. The impact of existing initiatives that have been developed to address similar concerns, such as ‘Assessing Pupils’ Progress’ in the UK (Thompson, 2010), should be researched and considered carefully before copying such initiatives.

It is also suggested that teachers are mindful of the benefits of emotions which may be perceived as negative, such as temporary frustration, which can increase the satisfaction of eventual success and promote perseverance and learning. While it is necessary to create a safe environment in which children can learn from mistakes, there is a danger in overprotecting students by reducing challenges for them so that mathematical work is always presented as an exercise to complete:

> Your problem may be modest; but if it challenges your curiosity and brings into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery. …If he [the teacher] fills his allotted time with drilling his students in routine operations, he kills their interest. (Pólya 1971, p. v)

Schools could consider and promote more inclusive options for catering to the diverse range of student abilities and needs in mathematics education. These considerations may include restructuring support, so that supporting adults come into the classroom rather than students going out. Teachers need to be cognisant of research that indicates the benefits of having high expectations of all students, and be willing to expose all students to high level content, with group work organised around social strengths. In combination with this, to achieve equity in mathematics education and address the achievement gap it would also be necessary for policymakers, school leaders and teachers to review the demands and requirements placed on teachers - given a deeper understanding of the complex nature of teaching and learning mathematics – so that time is made available for students to benefit from opportunities for consolidation, and for deep and transfer learning.

The findings reveal that many teachers experience feeling time-poor, with this directly impacting mathematics education. Of particular interest to policymakers is the widely held perception, by the teachers in this study, that the curriculum is crowded. It is recommended that the content and presentation of the curriculum is reviewed. Topics to explore during this review could include: the possibility of reducing content or deferring certain topics; removing year-level expectations, thereby encouraging teachers to recognise where each student is and focus on moving them on from there; and consideration of how expectations are communicated to ensure teachers are aware what the mandatory requirements are, as opposed to ideas or recommendations. The findings indicate that teachers perceive it to be necessary to cover all of the curriculum for their year level within the academic year – if this is not the intention of the curriculum documents then this needs to be more clearly communicated to teachers.

It may also be helpful for school leaders to be cognisant of the impact of teachers feeling that they need to rush through content or move on before students are ready. It is recommended that they review the external requirements placed on teachers and support teachers in finding time for students to consolidate mathematics learning, to explore concepts more deeply, and to transfer skills. One strategy which could offer support of this may be to reduce barriers to an integrated approach. For example, by ensuring all students are in the same place, rather than streamed for mathematics or withdrawn for extension or support. It is acknowledged that more research into inclusive interventions would be helpful in facilitating this.

It may be of interest to PL providers that teachers would welcome time-efficient and engaging strategies to teach mathematics, for instance through an integrated approach. As the participants indicated that it can take time to plan this way, and it is not time-efficient for each individual teacher to have to search for appropriate connections, then materials that make connections clear - between mathematics topics and between mathematics and other areas of the curriculum - could be well received. Research has already begun, describing connections between the big ideas in mathematics, science and technology (Hurst, 2015b) and exploring the complexities of developing an appropriate STEM curriculum (Chalmers, Carter, Cooper, & Nason, 2017). Resources for teachers have also been created by the national reSolve program, the ambitions of which include making mathematics "purposeful" through an inquiry approach, "connecting mathematics through deep linkages to other mathematical ideas and to other areas of the curriculum" (Australian Academy of Science, 2020). It is recommended that research continues in this area and related resources are well publicised. While the Australian curriculum addresses such links and provides some clear examples in the rationale (Australian Curriculum, Assessment and Reporting Authority, n.d.b), further specific examples are either absent or difficult to find within the mathematics learning area of the curriculum.

It certainly cannot be concluded from this study that the pressures teachers are under and the experience of being time-poor is detrimental to the teaching of all primary school subjects. However, it does appear to significantly impact teachers' experiences of mathematics education, and restrict teacher choices in a way that reduces opportunities for their students to enjoy and succeed at mathematics. With a student's early educational experiences affecting later learning, and low mathematical achievement negatively affecting overall learning and opportunities in life, it is essential for these concerns to be addressed.

It is apparent that, to address Australian students' achievement in mathematics, the solutions are not purely mathematics-specific, but lie in addressing a wider educational issue: time. This brings into question: What are we trying to achieve in primary schools in Western Australia? What are our values? How are these reflected in our policies and actions? Is it important for primary school children to be exposed to such a range of content that each area can only be explored at a surface level, or is success at primary school when children develop a love of learning, along with strong foundational personal and academic skills that will stand them in good stead for high school and later life? If it is the latter, does the current system facilitate or hinder this endeavour?

The findings indicate that it is possible that many of the answers regarding mathematics education exist in current literature, but the context within which teachers work prevents teachers from implementing recommendations effectively. It appears that the 'one size fits all' system, which places higher academic expectations on primary school children than ever before, is placing students and teachers under increasing pressure while simultaneously taking away the luxury of time needed to really develop confidence and curiosity.

In future reform agendas, a focus on giving teachers and students the necessary time and space to experience genuine delight in teaching and learning would be beneficial. Given a better understanding of the complexities of the role of teaching mathematics, as well as the impact of the context within which it is taught, it is suggested to reconsider priorities in primary school education, and how best to achieve these. By focusing on values and a philosophy of education that nurtures the whole child, teachers and students will be better able to thrive in our education system, and it is likely that a by-product of this would be increased 'performance'.

6.2 HOW DO PRIMARY SCHOOL TEACHERS PERCEIVE THEIR EXPERIENCES OF MATHEMATICS EDUCATION TO HAVE CHANGED DURING THEIR CAREER?

All the teachers in this study felt that they had improved in their ability to teach mathematics during their careers. The participants' early career experiences varied, but all described feeling somewhat unprepared when they first started teaching. The teachers reported experiencing the most growth through teaching in the classroom, combined with reflective practice. Growth appears to be further enhanced through changes in year level or school.

While all the participants in this study displayed a positive disposition towards teaching mathematics, some indicated that their feelings about mathematics had changed during their career. Changes in enthusiasm for and enjoyment of teaching mathematics was attributed to their own personal growth and confidence, as well as changes in school.

The findings indicate that different schools appear to vary significantly. Different schools encourage different pedagogical approaches to mathematics education, in line with the individual school's focus and values. These different working environments significantly impact a teacher's experience of mathematics education, affecting the teaching approaches they adopt and how well their practice aligns with their own beliefs and values. Variability between schools can also occur in terms of the collegial support and resources available, as well as the general characteristics of the students. For example, one participant described how, at another school she had worked at, a lot more time was required for behaviour management, taking away from teaching time.

This study did not reveal evidence of continuous PL occurring, with many of the participants not having engaged in mathematics PL by personal choice for some time. However, at both schools, collegial support was available and compulsory internal PL sessions had been organised, both of which were highly valued. In terms of the internal support and resources available, one participant described the experience of changing schools as "from nothing to everything, like that" (Sam). Sam also reflected on conversations she has had with teachers at different schools:

> They always say ‘you have that there’ then I’d say ‘yeah, we’re lucky’. But they don’t, but they should … how can we improve the standards if we’re not all equipped correctly … practical mathematical teaching workshops … needs to be ongoing, for every teacher … for their whole career. (Sam)

In terms of PL, none of the participants in this study were proactively accessing education research, unless in a leadership role. However, while this may suggest that there might generally be a persistent gap between research and practice, it should be noted that the leaders in these schools were doing their best to transfer their knowledge and experience to their colleagues, by offering both informal collegial support and by coordinating internal PL opportunities.

Informal collegial support was typically sought when teachers needed ideas on how best to meet individual student needs. Descriptions included situations where: the teacher had exhausted all their teaching ideas and a student was still not understanding a topic; student(s) at a higher year level had gaps in their knowledge and the teacher needed ideas regarding how to support the student to address these gaps; student(s) had mastered the content for their year level and the teacher needed ideas regarding how to extend their learning.

6.2.1 Implications and Recommendations

The findings reveal that all teachers felt unprepared at the start of their teaching career, and have grown mostly through reflective practice, school organised PL opportunities, and collegial support. These findings have implications for teacher training institutions, policymakers and school leaders.

As most growth occurs through teaching experience, it is recommended that teacher training institutions consider increasing practicum hours. It is also suggested that a review is conducted regarding the consistency and type of support provided for graduate teachers, with a specific focus on how graduates are supported in progressing from Graduate to Proficient as outlined in the AITSL standards (Australian Institute for Teaching and School Leadership, 2018). It is recognised that, if graduates begin their career in a public school in Western Australia, they will now have access to the Graduate Teacher Induction Program that was introduced in 2006, specifically to address these concerns. The findings of this study substantiate the necessity for the introduction of such a program. Given the importance of such an intervention, research into the effectiveness of this program would be beneficial.

Of particular interest to school leaders are the findings that well-resourced schools, that provide collegial support and organise on-site PL, ameliorate teachers' experiences of mathematics education. While few teachers had recently sought external PL opportunities for mathematics, all spoke of the benefits received from consultants who had come to the school with ideas and strategies for planning and teaching. It is therefore recommended that school leaders focus on bringing in consultants who can facilitate whole school agendas and offer support for all staff, in preference to individual teachers attending one-off external sessions.

It is also recommended that school leaders review internal support structures. Both of the schools in this study had either a member of staff in an administrative leadership role or a teacher in charge of each subject area who ensured all teachers were adequately supported. The findings indicate that this model could be successful, on the basis that: having a designated expert in mathematics to turn to for advice was clearly valued by the teachers in this study; and having one person responsible for keeping up to date with mathematics education research, then passing on advice and information to their colleagues, is a time-efficient and economical way to bridge the gap between research and practice.

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Appendices

Appendix A

Table 2: Interview Guide

Table 2

Interview Guide

Interview Questions	Further **prompt, *if necessary***
1. What feelings do you associate with mathematics education?	What dimensions, incidents and people intimately connected with mathematics education stand out for you?
	What thoughts stood out for you?
	What bodily changes or states are you aware of when you teach mathematics?
	How do these experiences affect you?
	How does your experience of teaching primary school mathematics affect significant others in your life?
	How do your feelings and views of mathematics compare to other subjects you teach?
2. Can you describe how your working environment colours and shapes your experience of mathematics education?	How would you describe your current role in mathematics education? How does this compare to the role you think you should play?
	How do you feel about teaching students mathematics as part of the school curriculum?
	What do you think works particularly well with the mathematics curriculum?
	Tell me about what barriers you face in completing the mathematics curriculum.
	How do targets from your school improvement plan impact on your practice in the classroom and in your engagement with colleagues?
3. Can you describe your experience of professional growth with respect to mathematics education, from when you qualified as a teacher until now?	Tell me about how you choose what to engage in, in terms of professional learning activities.
	Tell me about how you identify your professional learning needs.
	What has been your experience of accessing what you need?

	Can you tell me about any experiences of being a participant in, or consumer of research into mathematics education?
	Can you tell me about any conversations, research or professional learning activities that have triggered significant changes in your classroom practice?
	Have you felt any shifts in how driven you have been in addressing mathematics education? Why do you think that is?
4. Tell me about the challenges and successes you have in teaching mathematics?	Tell me about the influences you think mathematics has on: a student's knowledge, learning in other areas, and in their life.
	When you are concerned about student achievement in mathematics in your classroom what prompts these concerns? How concerned are you with the general achievement of all students in mathematics? Where do you think these concerns come from?
	Can you tell me about your experience and perspectives of published student assessments, such as NAPLAN?
	Tell me about your experiences of making connections between mathematics concepts and between mathematics and other areas of the curriculum? What motivates you to provide these connections?
	How influential do you believe you, specifically, are in changing students' mathematics knowledge and abilities?
	Can you describe your experiences when you encounter students who are not interested in mathematics or appear to struggle with mathematics?
	How do these experiences affect you?
5. Is there anything else you would like to share about your experiences and perceptions of teaching and learning mathematics?	

Note. Interview questions were adapted from Hall, Chai and Albrecht (2016, p. 138), and Moustakas (1994, p. 116).

Appendix B

Interview Transcript and Horizon Statements, Stacey

This chapter ‘Appendix B’ is not available in this version of the thesis.

Appendix C

Individual Narratives for All Participants

This chapter ‘Appendix C’ is not available in this version of the thesis.

Appendix D

Interview Transcript, Invariant Constituents and Themes, Gemma

This chapter ‘Appendix D’ is not available in this version of the thesis.